KANNUR UNIVERSITY

(Abstract)

FYIMP in Computational Science offered jointly by the Dept of Information Technology, Dept of Statistical Sciences & Dept of Mathematical Sciences - Scheme & Syllabus-- Approved -- Implemented w. e. f .the academic year 2024-'25 -- Orders Issued

ACADEMIC C SECTION

ACAD C/ACAD C3/7453/2024 Dated: 21.08.2024

Read:-1. U.O. No.Acad C3/22488/2023 dtd.15.03.2024

2. U.O No. ACAD H/ACAD H3/4513/2024 dated 15/05/2024

3. Minutes of the meeting of the FYIMP Implementation Committee held on 01/04/2024

4. U.O of even number dated 15/06/2024

5. Minutes of the FYIMP Scrutiny Committee held on 18/06/2024

6. Emails received from the Heads/ Course Director of FYIMP offering Depts.

7. The Minutes of the meeting of the Academic Council held on 25/06/2024

ORDER

1. As per paper read (1) above, the Regulations for the Five Year Integrated Master's Programme (FYIMP) in University Teaching Departments/Schools were implemented w.e.f. the academic year 2024-25.

2. Accordingly, Five Year Integrated Masters Programmes (FYIMP) viz, Physical Science, Computational Science, Clinical Psychology, Anthropological Sciences were commenced at various Campuses of Kannur University during the academic year 2024-25. Further, the ongoing Five Year Integrated Master of Physical Education and Sports and Five Year Integrated M.Com. programmes come under the FYIMP pattern w.e.f. the academic year 2024-25.

3. As per paper read as (3) above, the Meeting of the FYIMP Implementation Committee suggested the Heads/ Course Directors of the Teaching Depts concerned to conduct one day Workshop for finalizing the Syllabus of the FYIMP and to submit the same to the University for approval.

4. Heads/ Course Directors submitted the Syllabi accordingly.

5. Later on, as per the paper read as (4) above, an FYIMP Scrutiny Committee was constituted to scrutinize the Syllabi submitted by the Heads/ Course Directors of the FYIMP offering Departments.

6. The FYIMP Scrutiny Committee, scrutinized the FYIMP Syllabi submitted by the Heads/ Course Directors concerned. The FYIMP offering Heads/ Course Directors were informed to submit the final Draft of the Syllabi, after incorporating the Modifications/Corrections suggested by the FYIMP Scrutiny Committee, along with the Minutes of the Department Council, approving the Syllabus.

7. As per paper read (6) above, the Heads of the Depts/Course Directors, offering FYIMP submitted the final Draft Syllabi, seeking approval.

8. The same was placed before the meeting of the Academic Council held on 25/06/2024, for consideration.

9. The XXVIII meeting of the Academic Council, as per the paper read as (7) above, approved the Syllabus of the FYIMP in Computational Science, along with other five FYIMPs, to be commenced at various Campuses of the University w.e.f. 2024-'25 academic year, in principle and permitted to publish the same, considering the urgency of the matter.

10. The Minutes of the Academic Council was approved by the Vice Chancellor and published.

11. Therefore, the approved Syllabus of FYIMP in Computational Science, offered jointly by the Dept of Information Technology, Dept of Statistical Sciences & Dept of Mathematical Sciences, is attached with this UO and uploaded in the website of the University (www.kannuruniversity.ac.in).

Orders are issued accordingly.

KANNUR UNIVERSITY CIVIL STATION P.O. KANNUR Pin-670 002 THAVAKKARA

Sd/-
ANIL CHANDRAN R
DEPUTY REGISTRAR (ACADEMIC)
For REGISTRAR

To:
1. Head, Dept of IT
2. Head, Dept of Statistical Sciences
3. Head, Dept of Mathematical Sciences
4. Nodal Officer , FYIMP

Copy To:
1. PA to CE (To circulate the same among the Sections concerned under Examination Branch)
2. JR (Eaxam)
3. EP IV/ EG I/ EXC I (Exam)
4. IT Cell (to publish in the website)
5. Computer Programmer
6. PS to VC/ PA to R
7. SF/DF/FC

Forwarded / By Order
SECTION OFFICER

DEPARTMENT OF INFORMATION TECHNOLOGY

DEPARTMENT OF MATHEMATICAL SCIENCES

DEPARTMENT OF STATISTICAL SCIENCES

KANNUR UNIVERSITY

DEGREE OF

FIVE YEAR INTEGRATED PROGRAMME IN MSc COMPUTATIONAL SCIENCES

(CHOICE BASED CREDIT AND SEMESTER SYSTEM)

SCHEME & SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2024 – 25 ONWARDS)

Table of Contents

SCHEME AND SYLLABUS FOR THE DEGREE OF

MSc COMPUTATIONAL SCIENCES

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2024 – 25 ONWARDS

1 PROGRAMME SPECIFIC OUTCOMES

SL #	Outcome
PSO1	Familiar with the enhanced concepts of Computational Sciences
PSO2	Attain skills to address research problems in computational science discipline
PSO3	Equip the student to attain the skill required for Industry and academia
PSO4	Enhance the knowledge about emerging topics in Science and Technology and their applications
PSO5	Promote multidisciplinary research and development activities

DEFINITIONS

- Department / School is the department / school established in the Kannur University as per the statute of Kannur University.
- Academic programme is an entire course of study comprising the details such as the programme structure, course details, and evaluation schemes designed to be taught and evaluated in the teaching department / centre or jointly under more than one such department / centre.
- Course is a segment of a programme limited to one semester subject.
- Programme Structure is a list of courses (Core Courses, Elective Courses, Ability Enhancement Courses, Value Added Courses, Skill Enhancement Courses, and MOOC) that makes up an academic programme, specifying its details such as the syllabus, credits, hours of teaching, evaluation and examination schemes, and the minimum number of credits required for successful completion the programme prepared in conformity with the FYIMP regulations-2024 of Kannur University.

- Discipline Specific Core (DSC) is a course that is to be compulsorily completed by a student admitted to a particular programme to receive the degree and which cannot be substituted by any other course.
- Discipline Specific Elective(DSE) is an optional course to be selected by a student out of such courses offered in the same department or other departments.
- Joint Department Council (JDC), is a council consists of all teaching faculties of Dept. of Information Technology, Dept. of Mathematical Sciences and Dept. of Statistical Sciences.
- Wherever in this document "the University" is mentioned, it should be taken as the Kannur University and wherever "the Department" is mentioned, it should be taken as the department concerned with the respective course is offered.

2 SCOPE

1) This regulations shall apply to FYIMP- MSc Computational Science with multiple pathways, conducted jointly by three departments, namely; The Department of Information Technology, The Department of Mathematical Sciences and The Department of Statistical Sciences, Kannur University.

2) Choice Based Credit Semester System presupposes academic autonomy, cafeteria approach in academic environment, semester system, course credits, alphabetical grading, and inter departmental academic collaboration. There shall be a joint department council consisting of all teachers of Department of Information Technology, Department of Mathematical Sciences and Department of Statistical Sciences. The Convenor of joint department council will coordinate the activities of this programme. The convenor will be a permanent faculty from any of the three participating department decided by the JDC. The convenor shall coordinate the admission process to the FYIMP programme offered by the three departments. Records associated with each students should be maintained by the corresponding department based on the pathway courses chosen by the student in addition to the central record keeping facility maintaining for this programme. The major responsibility of convener- JDC will be at the first year of the FYIMP program of every batch of the admission; there after the student will be attached to the department concerned based on the pathway courses opted by the students. Convener of the joint department council will constitute a joint departmental admission committee comprising faculties from

Department of Information Technology, Department of Mathematical Sciences and Department of Statistical Sciences to assist them in the admission process. The joint-department council will deliberate on courses and specify the distribution of credits semester wise and course wise. Details such as the number of credits for lectures, tutorials, and practical will also be specified for each course by the corresponding department council who offer the specified course.

3) The Name of degree awarded when a student take exit at 3rd /4th/5th year is specified in the different pathways mentioned as part of this regulation. "*The Name "Computational Science" is only for indicating the broad spectrum of programs not for awarding the degree"*.

4) All three participating departments (Department of Information Technology, Department of Mathematical Sciences and Department of Statistical Sciences) have equal stake and responsibility for the Five Year Integrated MSc (Computational Science) Program and unconditional academic and administrative support should be offered by all three participating department irrespective of the number of students who chose the various pathways.

3 ADMISSION

1) Admission to the FYIMP MSc Computational Science programme will be done as the regulations prescribed by the university from time to time.

Eligibility for Admission:

Basic qualifications: Candidate must possess

1) pass with 50% marks/equivalent grade at 10+2 level or equivalent

AND

2) Mathematics/statistics/computer science/computer application/ informatics practices as one of the subjects at 10+2 level.

Admission to the FYIMP MSc Computational science programmes shall be made purely based on the entrance examination conducted by the university. Notification In this regard shall be made well in advance. If the number of candidates admitted based on the entrance examination is less than the sanctioned strength, the department can fill the vacancy by advertising the vacancy through press releases. Admission to these seats should be granted based on the marks obtained by the candidates in the qualifying examination.

Reservation norms followed by the university should be adhered to in the admission process.

4 Registration

Since students have flexibility to choose various courses and pathways, every student should register for a course for the next semester by end of the previous semester (except the first semester). Any changes in the selection of the courses are permitted up to the 5 working days of the start date of the new semester. The offering department can decide on the minimum / maximum number of registrations for a course depending on the instructional facilities and teachers availability for the listed courses. While choosing the courses students are advised to discuss with semester coordinator/ faculty advisor and also ensure that, the credit requirement for awarding the degree in various pathways as per FYIMP-2024 regulations are satisfied . Student can register for additional courses including MOOCs from second semester onwards, provided the total number of courses registered for that semester is not more than 30.

5 Programme Structure

1) Duration of the FYIMP Computational Science programme shall be 5 years, divided into 10 semesters. Each semester shall have 18 weeks. Students can take exit at 3rd / 4th /5th year as mentioned in the FYIMP regulations-2024-25. The Name of the degree awarded to each student will be depending on the pathway courses opted by the students while taking exit at above mentioned years. Different Pathways and corresponding names of degree awarded is mentioned in the below diagram

Exit	Pathways		
3rd Year Exit	Single Major Option		
	BSc (Computer Science)	BSc (Mathematics)	BSc (Statistics)
	Other Pathways As per the Regulations		
	BSc (CS Major with Mathematics / Statistics Minor)		
	BSc (Mathematics Major with CS / Statistics Minor)		
	BSc (Statistics Major with CS / Mathematics Minor)		
	BSc Double major in the any two combination CS/Statistics/ Mathematics)		
	BSc Multidisciplinary/ Interdisciplinary degree as per regulation		
4th Year Exit	BSc (Hons) (Computer Science)	BSc (Hons) (Mathematics)	BSc (Hons) (Statistics)
	BSc (Hons with Research) (Computer	BSc (Hons with Research) (Mathematics)	BSc (Hons with Research) (Statistics)
	BSc (Hons) (Computer Science & Engineering)		BSc (Hons) (Biostatistics)
	BSc (Hons with Research) (Computer Science & Engg.)		BSc (Hons with Research) (Bio statistics)

Exit			
5th Year Exit	MSc (Computer Science)	MSc Mathematics	MSc Statistics
	MSc (Computer Science & Engineering		MSc Biostatistics

2) Minimum and maximum duration for completing the courses will be based on the FYIMP-2024 regulations
3) Any degree awarded after securing the minimum required credits for awarding the degree after the 3rd / 4th or 5th year exit will be based on the FYIMP 2024 regulations, except for BSc (Hons) (Computer Science and Engineering) [BSc (Hons) (CS&E)] and MSc (Computer Science and Engineering) [MSc (CS&E)]. For these two programmes / pathways, student should complete the additional MOOCs / Department offered courses of each one of minimum 45 hours duration i.e., equivalent to 3 credit in addition to the other credited pathway courses. The options for awarding the [BSc (Hons) (CS&E)] and [MSc (CS&E)] are mentioned below
4) A student take exit at 4th year can opt For BSc (Hons) (Computer Science and Engineering) provided that the student should pursue the pathway courses designed for BSc. Hon. (CS&E) in second, third and fourth semester and also should complete at least 2 SWAYAM MOOCs (Approved by department) / courses offered from the department of minimum 3 credits each. If a student fails to submit a pass certificate in MOOCs/ Courses offered from the Department ; the student will be awarded with BSc Hons (Computer Science) provided the student completed the requirements of the BSc Hons (Computer Science) programme adhering with FYIMP-2024 Regulations. The additional 6 credits earned through the SWAYAM or Department courses will not be counted for computing the CGPA. Details of such courses will be listed in the final marks card, issued by the university. Students are permitted to register for the additional MOOCs from the second semester onwards; so that pass certificate for the additional MOOCs can be submitted by end of 8th semester.
5) Upon completion of the 5th year; a student will be awarded MSc (Computer Science and Engineering) if the student completed the requirement of BSc(Hons) (Computer Science and Engineering) and also earned the minimum credit requirement for MSc (Computer Science) program along with one course from the department or from SWAYAM/ MOOC platform of minimum 3 credits approved by the department. This credit will not be counted for computing CGPA, However a pass in this course is a must for awarding the MSc (Computer Science & Engineering) falling which MSc (Computer Science) will be awarded, provided that the minimal requirement for awarding MSc

(Computer Science) is acquired by the student. Details of additional credits earned will be listed in the final marks card, issued by the university. Students are permitted to enroll for the additional MOOC at 9th semester itself so that a pass certificate can be submitted by the end of 10th semester.

6) Student who take exit at 4th Year will be awarded BSc (Hon) or BSc (Hon with Research) in Statistics or Bio-Statistics and exiting at 5th year will be awarded MSc (Statistics) or MSc (Bio Statistics) provided the student has earned the required credits form the respective pathways courses prescribed for the above programme mentioned in the path way courses for Statistical Science.

7) A model course pathway structure for various disciplines (Computer Science, Mathematics and Statistics) are mentioned as part of this syllabus. The mentioned structure is only for understanding purpose; However students can chose courses from the various disciplines as mentioned in FYIMP regulations. The awarding of major and minor in a given discipline is subjected to minimum credit requirement and also mandatory pathway courses recommended for the discipline.

8) For every course a module X is included; which is teacher specific module. The content mentioned in module X is only a tentative direction/ advanced topic, so that teachers are free to design the content based on their perception.

6 MOOC

1) In addition to the courses specified as part of the programme, all students should mandatorily complete 2 MOOCs of at least 3 credits to complete the requirements of getting BSc (Hons) degree in any of the discipline. The credits earned will be considered for the computation of GPA and CGPA.

2) For BSc (Hons) (Computer Science and Engineering)and MSc (Computer Science and Engineering) additional MOOCs or courses offered by the department should be successfully completed as stated in the section 5 – program structure.

7 EVALUATION

The Continuous and Comprehensive Evaluation (CCE) and the End semester Evaluation (ESE) will be conducted as per the Kannur University FYIMP Regulations- 2024 for all theory and practical courses unless it is specifically mentioned in the respective courses. The ratio of Continuous and Comprehensive Evaluation and End semester Evaluation will be 50:50.

End Semester Evaluation

End semester Evaluation will be conducted as per FYIMP Regulations-2024.

The course for the FYIMP- Computational Science programs have either 3 credit or 4 credit courses across various course categories i.e., DSC, DSE,AEC,SEC,VAC,MOOC, Internship. The credit for a given course is typically distributed as follows

Distribution Teaching / Learning hours for 4 Credit Course

1. 4 Credit Lecture session
2. 3 Credit Lecture Sessions and 1 Credit Practical
3. 2 Credit Lecture Session and 2 Credit Practical
4. 1 Credit Lecture Session and 3 Credit Practical
5. 4 Credit Practical Sessions

Similarly Distribution Teaching / Learning hours for 3 Credit Course

1. 3 Credit Lecture session
2. 2 Credit Lecture Sessions and 1 Credit Practical
3. 1 Credit Lecture Session and 2 Credit Practical
4. 3 Credit Practical Sessions

End Semester Examination for all these different combinations are as Follows

ESE Scheme for 4 Credit courses		
1	4Credit Theory	Theory Examination of 50 marks . Duration of Examination 2 Hours
2	3 credit Lecture and 1 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 37.5 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 12.5 • Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
3	2 credit Lecture and 2 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 25 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 25
		• Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	1 credit Lecture and 3 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 12.5 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 37.5 • Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	4 Credit Practical	Practical Examination of 50 marks . 3 hours Duration

ESE Scheme for 3 Credit courses (SEC/MDC/VAC) offered Dept. of IT/ Mathematics / Statistics		
	3 Credit Theory	ESE will be conducted for 50 marks
	2 Credit theory and 1 Credit Practical	ESE (Theory) Max marks : 50; Duration : 2 Hours scaled to 30 marks ESE (Practical) Max marks : 50; Duration 2 Hours scaled to 20 marks Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	1 Credit for Theory and 2 Credit for Practical	ESE (Theory) Max marks : 50; Duration : 2 Hours scaled to 20 marks ESE (Practical) Max marks : 50; Duration 2 Hours scaled to 30 marks Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	3 Credit Practical	ESE will be conducted for 50 marks

If any changes in the evaluation patten for any courses it can be mentioned in the assessment rubrics of the corresponding course. Other wise it will be followed the above rubrics corresponding to their credit.

Continuous and Comprehensive Evaluation (CCE).

CCE for all courses shall follow the FYIMP- Computational Science -Scheme and syllabus -2024 unless it is specifically mentioned in the course syllabus. Where ever there is a practical component associated with a course; Lab test will be conducted as part of CCE, in addition to the other evaluation methods mentioned in FYIMP-Regulations 2024 for CCE. The division of CCE marks for different courses structure shall be as follows.

Course structure	Continuous Assessment
4 Credit course	**Total Marks : 50** • Test paper 1 : 15 • Test Paper 2: 15 • Assignment : 10 • Seminar /Viva : 10
4 Credit course (3 Lecture+ 1 Lab)	**Total Marks : 50** • Test 1 : 10 • Test 2 : 10 • Lab Test and viva : 15 • Record : 5 • Assignments/case study/ seminar : 10
4 Credit (2 Credit Lecture and + 2 Credit Practical)	**Total Marks : 50** • Test 1 : 10 • Test 2 : 10 • Lab Test and viva : 15 • Record : 5
	• Assignments/ case study/ seminar : 10
4 Credit (1 Credit Lecture + 3 Credit Practical)	**Total Marks 50** • Test paper 1 : 5 • Test Paper 2: 5 • Lab test 1 and viva : 10 • Lab Test 2 and viva : 10 • Lab record : 5 • Seminar/ Assignments / Case Study : 15

4 Credit Practical	Total Marks • Lab test 1 and viva : 20 • Lab test 2 and viva : 20 • Record : 10
3 Credit Courses (MDC/SEC/VAC) offered by the IT/Maths/Statistics	
3 credit Lecture	**Total Marks 50** • Test 1 : 15 • Test 2 : 15 • Seminar /Assignment/ Case Study : 20
2 Credit Lecture + 1 Credit practical	**Total Marks 50** • Test 1 : 10 • Test 2 : 10 • Lab test : 15 • Record : 5 • Seminar/Assignment / Case study : 10
1 Credit Lecture and 2 Credit Practical	**Total Marks 50** • Test 1 : 5 • Test 2: 5 • Lab test with Viva : 25 • Record : 5
	• Assignment / Case study/ Seminar : 10
3 Credit Lab	**Total Marks 50** • Lab test 1 and viva : 20 • Lab test 2 and viva : 20 • Record : 10

The end semester practical examination will be conducted by a board of examiners constituted by the Head of the department of the course offered. The board of examiners consist of 2 faculty members and one should be the faculty in charge of the respective course. Total minimum requirement for every CCE component for a pass shall follow the minimum requirement mentioned in FYIMP-2024 regulations. If any other mode of assessment is proposed for a specific course; the assessment rubrics should be mentioned in the syllabus separately associated with that course. Otherwise evaluation scheme mentioned in the regulations shall be applicable for both CCE and ESE.

Evaluation criteria for the Research, Internship components will follow the criteria mentioned in FYIMP-2024 regulations.

8 Compliances with FYIMP- Regulations -2024

In general, FYIMP – Computational Science programs follows the FYIMP-regulations approved by university unless it is specifically mentioned here. Joint department council have a right to revise the scheme and syllabus based on the feed back and input from various stake holders of the program.

COMPUTER SCIENCE/ COMPUTER SCIENCE AND ENGINEERING COURSES

COMPUTER SCIENCE/ COMPUTER SCIENCE AND ENGINEERING COURSES

Semester I

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
1.1	100	KU1DSCCSE101	Principles of Programming	4	2	4	1	50	50	100

Semester II

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
2.1	100	KU2DSCCSE102	Foundations of Computer Science	4	2	4	1	50	50	100
2.2	100	KU2DSCCSE103*	Engineering Design and Prototyping	4	2	4	1	50	50	100
2.3	100	KU2DSCCSE104	Basic Science and Applications	4	2	4	0	50	50	100

NOTE : KU2DSCCSE103 for BSc (Hons) (CSE) and MSc (CSE) ; KU2DSCCSE104 for BSc (CS) and BSc (Hons) (CS) and MSc (CS) is a joint course offered by Dept. of Wood Science and Technology jointly with Dept. of IT

Semester III

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3.1	200	KU3DSCCSE201	Introduction to Data Structure	4	2	4	1	50	50	100
3.2	200	KU3DSCCSE202	Object oriented Programming using C++	4	2	4	1	50	50	100
3.3	200	KU3DSCCSE203	Engineering Physics	4	2	4	1	50	50	100
3.4	200	KU3DSCCSE204	Scientific Computing	4	3	2	1	50	50	100

Semester IV

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4.1	200	KU4DSCCSE205	Database Management System	4	2	4	1	50	50	100
4.2	200	KU4DSCCSE206	System Software and Operating System	4	3	2	1	50	50	100
4.3	200	KU4DSCCSE207	Digital Electronics and Computer Organization	4	4	0	1	50	50	100
4.4	300	KU4DSCCSE301	Foundations of Electrical and Electronics Engineering	4	3	2	1	50	50	100
4.5	200	KU4DSCCSE208	Data and Business Analytics	4	3	2	1	50	50	100

Semester V

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5.1	300	KU5DSCCSE302	Java Technologies	4	2	4	1	50	50	100
5.2	300	KU5DSCCSE303	Computer Network	4	2	4	1	50	50	100
5.3	300	KU5DSCCSE304	Software Engineering	4	4	0	1	50	50	100
5.4	300	KU5DSCCSE305	Machine Learning Techniques	4	2	4	1	50	50	100
5E.x	Elective IV -DSE (POOL D)			4	POOL D			50	50	100

S5 - List of Discipline Specific Electives (DSE) (POOL D)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5E.1	300	KU5DSECSE306	Operating System Security	4	3	2	1	50	50	100
5E.2	300	KU5DSECSE307	Introduction to Digital Forensic	4	3	2	1	50	50	100
5E.3	300	KU5DSECSE308	Mobile Computing	4	3	2	1	50	50	100
5E.4	300	KU5DSECSE309	Cloud, Edge and Fog Computing	4	4	0	1	50	50	100
5E.5	300	KU5DSECSE310	Geographical Information System	4	3	2	1	50	50	100

Semester VI

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6.1	300	KU6DSCCSE311	Analysis and Design of Algorithms	4	2	4	1	50	50	100
6.2	300	KU6DSCCSE312	Quantum computing	4	3	1	1	50	50	100
6.3	300	KU6DSCCSE313	Theory of Computation	4	4	0	1	50	50	100
6.4	Elective V – DSE (Pool E)							50	50	100
6.5	300	KU6INTCSE301	Internship	4	-	8	1	50	50	100

S6 - List of Discipline Specific Electives (DSE) (POOL E)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6E.1	300	KU6DSECSE314	IoT	4	3	2	1	50	50	100
6E.2	300	KU6DSECSE315	Big data analytics,	4	3	2	1	50	50	100
6E.3	300	KU6DSECSE316	Virtual and Augmented Reality	4	3	2	1	50	50	100
6E.4	300	KU6DSECSE317	Game Development	4	3	2	1	50	50	100
6E.5	300	KU6DSECSE318	Wearable Computing and sensors	4	3	2	1	50	50	100
6E.6	300	KU6DSECSE319	Computational Photography	4	3	2	1	50	50	100
6E.7	300	KU6DSECSE320	Design thinking	4	2	2	1	50	50	100
6E.8	300	KU6DSEEVS301* (Inter Disciplinary course jointly with EVS)	Environmental Engineering	4	3	1				

Semester VII

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7.1	400	KU7DSCCSE401	Signals and Systems	4	2	4	1	50	50	100
7.2	400	KU7DSCCSE402	Quantum gates and Circuits	4	3	2	1	50	50	100
7.3	400	KU7DSCCSE403	Artificial Intelligence	4	4	0	1	50	50	100
7.4	400	KU7DSCCSE404	Data Science	4	2	4	1	50	50	100
7E.x	Elective IV -DSE (POOL F)			4	POOL F			50	50	100
7M	MOOC / Online course Approved by Department KU7MOCCSE401			3						

S7 - List of Discipline Specific Electives (DSE) (POOL F)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7E.1	400	KU7DSECSE405	High performance computing	4	3	2	1	50	50	100
7E.2	400	KU7DSECSE406	Computer Vision	4	3	2	1	50	50	100
7E.3	400	KU7DSECSE407	Information Security	4	3	2	1	50	50	100
7E.4	400	KU7DSECSE408	Data and Information visualization	4	3	2	1	50	50	100
7E.5	400	KU7DSECSE409	Cryptography and Network Security	4	3	2	1	50	50	100

Semester VIII

No	level	Course Code	Course Name		C	Hrs./wk.			Assessment Weightage (%)		
						L	P	Tt	ESA	CE	T
8.1	500	KU8DSCCSE501	Generative AI		4	3	2	1	50	50	100
8.2	400	KU8RPHCSE401	Research/ Internship		12	24			50	50	100
OR											
8E.1	400	CODE FROM POOL G	DSE -1	From POOL G	4	3	2		50	50	100
8E.2	400		DSE-2		4	3	2		50	50	100
8E.3	400		DSE-3		4	3	2		50	50	100
8M	MOOC / Online course Approved by Department KU8MOCCSE402				3				--	--	--

S8 - List of Discipline Specific Electives (DSE) (POOL G)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
8E.1	400	KU8DSECSE410	Nature Inspired computing	4	3	2	1	50	50	100
8E.2	400	KU8DSECSE411	Robotics	4	3	2	1	50	50	100
8E.3	400	KU8DSECSE412	Time series analysis	4	3	2	1	50	50	100
8E.4	400	KU8DSECSE413	Natural Language Processing	4	3	2	1	50	50	100
8E.5	400	KU8DSECSE414	Fussy Systems and Logics	4	3	2	1	50	50	100
8E.6	400	KU8DSECSE415	Wireless Ad hoc Network							

Semester IX

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
9.1	500	KU9DSCCSE502	Applied Digital signal Processing	4	2	4	1	50	50	100
9.2	500	KU9DSCCSE503	Digital Image Processing	4	2	4	1	50	50	100
9.3	500	KU9DSCCSE504	Human Computer Interaction	4	2	4	1	50	50	100
9.4	500	KU9DSCCSE505	Advanced Data Structures and Algorithms	4	2	4	1	50	50	100
9.5	500	KU9DSCCSE505	Advanced Computer Network	4	2	4				

Semester X

No	level	Course Code	Course Name		C	Hrs./wk.			Assessment Weightage (%)		
						L	P	Tt	ESA	CE	T
10.1	500	KU8CIPCSE501	Research/ Internship		20	36			50	50	100
OR											
10E.1	500	CODE FROM POOL H	DSE -1	From POOL H	4	3	2	1	50	50	100
10E.2	500		DSE-2		4	3	2	1	50	50	100
10E.3	500		DSE-3		4	3	2	1	50	50	100
10E.4	500		DSE-4		4	3	2	1	50	50	100
10E.5	500		DSE-5		4	3	2	1	50	50	100

S10 - List of Discipline Specific Electives (DSE) (POOL H)

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
10E.1	500	KU10DSECSE506	Biometric Image Processing	4	2	4	1	50	50	100
10E.2	500	KU10DSECSE507	Cyber Forensic	4	2	4	1	50	50	100
10E.3	500	KU10DSECSE508	Algorithms in Computational Biology	4	2	4	1	50	50	100
10E.4	500	KU10DSECSE509	Visual Cryptography	4	2	4	1	50	50	100
10E.5	500	KU10DSECSE510	Software Defined Network	4	2	4	1	50	50	100
10E.6	500	KU10DSECSE511	Speech audio and video forensic	4	2	4	1	50	50	100

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4SE.1	200	KU4SECCSE201	Python Programming	3	2	2	0	50	50	100
4SE.2	200	KU4SECCSE202	Fundamentals of Digital Skilling using Google Workspace for Education	3	2	2	0	50	50	100

Semester 5 SEC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5SE.1	200	KU5SECCSE203	The Art of E - Documentation using Latex	3	2	2	0	50	50	100
5SE.2	200	KU5SECCSE204	Data Processing with Python	3	2	2	0	50	50	100
5SE.3	200	KU5SECCSE205	Data Science Fundamentals	3	2	2	0	50	50	100

Semester 6 SEC POOL 3										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6SE.1	300	KU6SECCSE301	Artificial Intelligence in Daily Life	3	2	2	0	50	50	100
6SE.2	300	KU6SECCSE302	Fundamentals of Big Data	3	2	2	0	50	50	100
6SE.3	300	KU6SECCSE303	Optimization Techniques	3	2	2	0	50	50	100
6SE.4	300	KU6SECCSE304	Web Technologies	3	2	2	0	50	50	100

MULTI DISCIPLINARY COURSES

Semester 1/Semester 2 MDC POOL 2										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
1MD.1	100	KU1MDCCSE101	Foundations of Information and Communication Technologies	3	2	2	0	50	50	100
2MD.2	200	KU2MDCCSE201	Foundations of Data Science	3	2	2	0	50	50	100

COMPUTER SCIENCE PATHWAYS

BSc (Computer Science)
BSc (Hons)/ BSc (Hons. With Research) (Computer Science)
BSc (Hons)/ BSc (Hons. With Research) (Computer Science & Engineering)
MSc (Computer Science)
MSc (Computer Science & Engineering)

Model Course Structure

BSc (Computer Science) – 3rd year Exit

Model Course Distribution for the BSc (computer Science) Programme with effect from 2024- 25 Onwards (3rd Year Exit)										
	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC /Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCCSE101& 2 Course from another department/ discipline (4 credit each)		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCCSE102 KU2DSCCSE104/KU2DSCCSE103* & 2 Course from another department (4 credit each)		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCCSE201 KU3DSCCSE202 KU3DSCCSE204/203 & 1 Course from other department (4 credit)		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU4DSCCSE205 KU4DSCCSE206 KU4DSCCSE207 KU4DSCCSE208/KU4DSCCSE301				SEC-1	VAC-2				
	12	4			3	3			6	22
5	KU5DSCCSE302 KU5DSCCSE303 KU5DSCCSE304	Elective POOL D Any One KU5DSECSE306			SEC-2					

	KU5DSCCSE305	KU5DSECSE307 KU5DSECSE308 KU5DSECSE309 KU5DSECSE310							6	23
	16	**4**			3					
6	KU6DSCCSE311 KU6DSCCSE312 KU6DSCCSE313	**Elective POOL E** **Any One** KU6DSECSE314 KU6DSECSE315 KU6DSECSE316 KU6DSECSE317 KU6DSECSE318 KU6DSECSE319 KU6DSECSE320 KU6DSEEVS301			SEC-3			KU6INTCSE301	6	23
	12	**4**			3			4		
	Total Credit earned									**133**

Model Course Structure

BSc Hons. (Computer Science) / BSc Hons. with Research (Computer Science) – 4th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/ Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCCSE101 And 2 Course from another department/ discipline (4 credit each)		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCCSE102 KU2DSCCSE104/KU2DSCCSE103 AND 2 Course from another department/ discipline (4 credit each)		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCCSE201 KU3DSCCSE202 KU3DSCCSE204/203 And 1 Course from another department / discipline (4C)		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU4DSCCSE205 KU4DSCCSE206 KU4DSCCSE207 KU4DSCCSE208/ KU4DSCCSE301				SEC-1	VAC-2			6	22
	12	4			3	3				

5	KU5DSCCSE302 KU5DSCCSE303 KU5DSCCSE304 KU5DSCCSE305	**Elective POOL D** **Any One** KU5DSECSE306 KU5DSECSE307 KU5DSECSE308 KU5DSECSE309 KU5DSECSE310			SEC-2				**6**	**23**
	16	**4**			**3**					
6	KU6DSCCSE311 KU6DSCCSE312 KU6DSCCSE313	**Elective POOL E** **Any One** KU6DSECSE314 KU6DSECSE315 KU6DSECSE316 KU6DSECSE317 KU6DSECSE318 KU6DSECSE319 KU6DSECSE320 KU6DSEEVS301			SEC-3			KU6INTCSE301	6	23
	12	**4**			3			4		
7	KU7DSCCSE401 KU7DSCCSE402 KU7DSCCSE403 KU7DSCCSE404	**Elective Pool F** **Any One** KU7DSECSE405 KU7DSECSE406 KU7DSECSE407 KU7DSECSE408 KU7DSECSE409					**MOOC-1** KU7MOCCSE401		6	24
	16	**4**					**4**			
8	KU8DSCCSE501	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) **Any three** KU8DSECSE410 KU8DSECSE411 KU8DSECSE412 KU8DSECSE413 KU8DSECSE414 KU8DSECSE415					**MOOC-2** KU7MOCCSE402	KU8RPHCSE401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

Model Course Structure

BSc Hons. (Computer Science & Engineering) / BSc Hons. with Research (Computer Science & Engineering) – 4th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCCSE101 KU1DSCMAT101 KU1DSCSTA101		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	**0**	**3**	**6**						
2	KU2DSCCSE102 KU2DSCCSE103 KU2DSCMAT101 KU2DSCSTA102/103		MDC -2	AEC-3					6	22
	16 Credits	0	3	**3**						
3	KU3DSCCSE201 KU3DSCCSE202 KU3DSCCSE203 And One Course from another department (4C)		MDC-3			VAC-1			6	22
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCCSE205 KU4DSCCSE206 KU4DSCCSE207 KU4DSCCSE301				SEC-1	VAC-2				
	12	**4**			3	**3**			6	22

5	KU5DSCCSE302 KU5DSCCSE303 KU5DSCCSE304 KU5DSCCSE305	**Elective POOL D** **Any One** KU5DSECSE306 KU5DSECSE307 KU5DSECSE308 KU5DSECSE309 KU5DSECSE310			SEC-2				6	23
	16	**4**			3					
6	KU6DSCCSE311 KU6DSCCSE312 KU6DSCCSE313	**Elective POOL E** **Any One** KU6DSECSE314 KU6DSECSE315 KU6DSECSE316 KU6DSECSE317 KU6DSECSE318 KU6DSECSE319 KU6DSECSE320 KU6DSEEVS301			SEC-3			KU6INTCSE301	6	23
	12	**4**			3			4		
7	KU7DSCCSE401 KU7DSCCSE402 KU7DSCCSE403 KU7DSCCSE404	**Elective Pool F** **Any One** KU7DSECSE405 KU7DSECSE406 KU7DSECSE407 KU7DSECSE408 KU7DSECSE409					**MOOC-1** KU7MOCCSE401		6	24
	16	**4**					**4**			
8	• KU8DSCCSE501	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) Any three KU8DSECSE410 KU8DSECSE411 KU8DSECSE412 KU8DSECSE413 KU8DSECSE414 KU8DSECSE415					**MOOC-2** KUMOCCSE402	KU8RPHCSE401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Additional MOOCs / Department course for 3 Credit for BSc (Hons) / BSc (Hons with Research) in Computer Science and Engineering.						***MOOC 3 & MOOC 4** KUMOCCSE403 KUMOCCSE404			
	Total Credit earned									**177**

*** MOOC 3 and MOOC 4 / Couse offered by the Department; at least of 3 credit each should be completed. Students can enrol for MOOC 3 and MOOC 4 from second semester onwards and a pass certificate can be submitted by 8th Semester for securing BSc Hons. / BSc Hons with Research (Computer Science & Engineering); however this credit will not be added for computing the CGPA.**

Model Course Structure-

MSc (Computer Science)– 5th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		**MDC**							
#	**Core Courses (DSC)**	**Electives (DSE)**	**IDE/MDC /Open**	**AEC 3 Credits**	**SEC 3 Credits**	**VAC**	**MOOC / Online**	**Internship**		
1	KU1DSCCSE101 And 2 Course from another department/ discipline (4 credit each)		MDC -1	AEC-1 AEC-2					**6**	**21**
	12 Credits	**0**	**3**	**6**						
2	KU2DSCCSE102 KU2DSCCSE104/KU2DSCCSE103* and 2 Course from another department/ discipline (4 credit each)		MDC -2	AEC-3					**6**	**22**
	16 Credits	0	3	**3**						
3	KU3DSCCSE201 KU3DSCCSE202 KU3DSCCSE204/203 and One course from other department / discipline		MDC-3			VAC-1			**6**	**22**
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCCSE205 KU4DSCCSE206 KU4DSCCSE207 KU4DSCCSE208/KU4DSCCSE301				SEC-1	VAC-2				
	12	**4**			3	**3**			6	22
5	KU5DSCCSE302 KU5DSCCSE303 KU5DSCCSE304 KU5DSCCSE305	**Elective POOL D Any One** KU5DSECSE306 KU5DSECSE307 KU5DSECSE308 KU5DSECSE309 KU5DSECSE310			SEC-2				6	23
	16	**4**			3					

6	KU6DSCCSE311 KU6DSCCSE312 KU6DSCCSE313	**Elective POOL E** **Any One** KU6DSECSE314 KU6DSECSE315 KU6DSECSE316 KU6DSECSE317 KU6DSECSE318 KU6DSECSE319 KU6DSECSE320 KU6DSEEVS301			SEC-3			Intenship KU6INTCSE301	6	23
	12	**4**			3			4		
7	KU7DSCCSE401 KU7DSCCSE402 KU7DSCCSE403 KU7DSCCSE404	**Elective Pool F** **Any One** KU7DSECSE405 KU7DSECSE406 KU7DSECSE407 KU7DSECSE408 KU7DSECSE409					MOOC-1 KU7MOCCSE401		6	24
	16	**4**					**4**			
8	• KU8DSCCSE501	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) Any three KU8DSECSE410 KU8DSECSE411 KU8DSECSE412 KU8DSECSE413 KU8DSECSE414 KU8DSECSE415					MOOC-2 KU7MOCCSE402	KU8RPHCSE401 **Research** for BSc Hons with Research – in lieu of 3 DSE course	6	20
	4	**12**					**4**	**12**		
9	KU9DSCCSE502 KU9DSCCSE503 KU9DSCCSE504 KU9DSCCSE505 KU9DSCCSE505 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU9CIPCSE501 KU9MOCCSE501			20
	20 /16/12						**0/4/8**			
10	**Research (20C)** **OR**									20
		5 DSE Courses from Pool H **Any Five** KU10DSECSE506 KU10DSECSE507 KU10DSECSE508 KU10DSECSE509 KU10DSECSE510 KU10DSECSE511								
		20								
	Total Credit earned									**217**

Model Course Structure

MSc(Computer Science & Engineering) 5th year Exit

#	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCCSE101 KU1DSCMAT101 KU1DSCSTA101		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCCSE102 KU2DSCCSE103 KU2DSCMAT101 KU2DSCSTA102/103		MDC -2	AEC-3						
	16 Credits	0	3	3					6	22
3	KU3DSCCSE201 KU3DSCCSE202 KU3DSCCSE203 and One course from other department (4 credit)		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU4DSCCSE205 KU4DSCCSE206 KU4DSCCSE207 KU4DSCCSE301				SEC-1	VAC-2				
	12	4			3	3			6	22

5	KU5DSCCSE302 KU5DSCCSE303 KU5DSCCSE304 KU5DSCCSE305	**Elective POOL D** **Any One** KU5DSECSE306 KU5DSECSE307 KU5DSECSE308 KU5DSECSE309 KU5DSECSE310			SEC-2				6	23
	16	**4**			3					
6	KU6DSCCSE311 KU6DSCCSE312 KU6DSCCSE313	**Elective POOL E** **Any One** KU6DSECSE314 KU6DSECSE315 KU6DSECSE316 KU6DSECSE317 KU6DSECSE318 KU6DSECSE319 KU6DSECSE320 KU6DSEEVS301			SEC-3			Intenship KU6INTCSE301	6	23
	12	**4**			3			4		
7	KU7DSCCSE401 KU7DSCCSE402 KU7DSCCSE403 KU7DSCCSE404	**Elective Pool F** **Any One** KU7DSECSE405 KU7DSECSE406 KU7DSECSE407 KU7DSECSE408 KU7DSECSE409					MOOC-1 KU7MOCCSE401		6	24
	16	**4**					**4**			
8	KU8DSCCSE501	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) Any three KU8DSECSE410 KU8DSECSE411 KU8DSECSE412 KU8DSECSE413 KU8DSECSE414 KU8DSECSE415					MOOC-2 KU7MOCCSE402	KU8RPHCSE401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
							***MOOC 3 &** **MOOC 4** KUMOCCSE403 KUMOCCSE404			

*** MOOC 3 and MOOC 4 / Couse offered by the Department; at least of 3 credit each should be completed. Students can enrol for MOOC 3 and MOOC 4 from second semester onwards and a pass certificate can be submitted by 8th Semester for securing BSc Hons. / BSc Hons with Research (Computer Science & Engineering); The credit will not be added for computing the CGPA.**

9	KU9DSCCSE502 KU9DSCCSE503 KU9DSCCSE504 KU9DSCCSE505 KU9DSCCSE505 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU9CIPCSE501 KU9MOCCSE501			20
	20/16/12						**0/4/8**			20
10	**Research (20Credit) KU10RPHCSE501 OR**									
		5 DSE Courses from Pool H Any five KU10DSECSE506 KU10DSECSE507 KU10DSECSE508 KU10DSECSE509 KU10DSECSE510 KU10DSECSE511					MOOC -5 KU9MOCCSE502			20
		20								
	Total Credit earned									**217**

*** MOOC 5/ Couse offered by the Department; at least of 3 credit should be completed. Students can enrol for MOOC 5 on 9th or 10th semester onwards and a pass certificate can be submitted by 10th Semester for securing MSc (Computer Science & Engineering); The credit earned will not be added for computing the CGPA.**

STATISTICAL SCIENCE COURSES

STATISTICAL SCIENCE COURSES

Semester I

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
1.1	100	KU1DSCCSE101	Descriptive Statistics	4	2	4	1	50	50	100

Semester II

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
2.1	100	KU2DSCSTA102	First Course on Theory of Probability	4	3	1	1	50	50	100
2.2	100	KU2DSCSTA103	Introduction to R Programming	4	2	4	-	50	50	100

Semester III

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3.1	200	KU3DSCSTA201	Theory of Random Variables	4	3	1	1	50	50	100
3.2	200	KU3DSCSTA202	Distribution Theory-I	4	3	1	1	50	50	100
3.3	200	KU3DSCSTA203	Matrix Theory	4	3	1	1	50	50	100
3.4	200	KU3DSCSTA204	Statistical Computing Using SPSS	4	1	6	1	50	50	100

Semester IV

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4.1	200	KU4DSCSTA205	Distribution Theory-II	4	3	1	1	50	50	100
4.2	200	KU4DSCSTA206	Sampling Theory	4	3	1	1	50	50	100
4.3	200	KU4DSCSTA207	Theory of Estimation	4	3	1	1	50	50	100
4.4	200	KU4DSCSTA208	Introduction to Biostatistics	4	3	1	1	50	50	100

Semester V

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5.1	300	KU5DSCSTA301	Theory of Markov Chain	4	3	1	1	50	50	100
5.2	300	KU5DSCSTA302	Mathematical Methods for Statistics-I	4	3	1	1	50	50	100
5.3	300	KU5DSCSTA303	Linear Regression Analysis	4	3	1	1	50	50	100
5.4	300	KU5DSCSTA304	Testing of Hypothesis	4	3	1	1	50	50	100
5E.x	Elective -DSE (POOL A)			4	POOL A			50	50	100

S5 - List of Discipline Specific Electives (DSE) (POOL A)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5E.1	300	KU5DSESTA305	Introduction to Actuarial Statistics	4	3	1	1	50	50	100
5E.2	300	KU5DSESTA306	Official Statistics	4	3	2	1	50	50	100

Semester VI

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6.1	300	KU6DSCSTA307	Time Series Analysis	4	3	1	1	50	50	100
6.2	300	KU6DSCSTA308	Design of Experiments	4	3	1	1	50	50	100
6.3	300	KU6DSCSTA309	Statistical Computing	4	-	6	1	50	50	100
6E.x	Elective – DSE (**Pool B**)							50	50	100
6.5	300	KU6INTCSE301	Internship	4	-	8	1	50	50	100

S6 - List of Discipline Specific Electives (DSE) (POOL B)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6E.1	300	KU6DSESTA310	Statistical Quality Control	4	3	1	1	50	50	100
6E.2	300	KU6DSESTA311	Statistical Machine Learning	4	3	1	1	50	50	100
6E.3	300	KU6DSESTA312	Statistical Methods Using Python	4	3	1	1	50	50	100

Semester VII

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7.1	400	KU7DSCSTA401	Measure and Probability	4	4	-	1	50	50	100
7.2	400	KU7DSCSTA402	Mathematical Methods for Statistics-II	4	4	-	1	50	50	100
7.3	400	KU7DSCSTA403	Advanced Distribution Theory	4	3	2	1	50	50	100
7.4	400	KU7DSCSTA404	Statistical Inference	4	3	2	1	50	50	100
7.5	400	KU7DSESTA405	Mathematical Methods for Biostatistics	4	4	-	1	50	50	100
7.6	400	KU7DSESTA406	Probability and Distribution Theory	4	4	-	1	50	50	100
7.7	400	KU7DSESTA407	Analysis of Clinical Trials	4	3	2	1	50	50	100
7.8	400	KU7DSESTA408	Biostatistical Inference	4	3	2	1	50	50	100
7E.x	400	Elective IV -DSE (**POOL C**)		4	POOL C			50	50	100
7M	MOOC / Online course Approved by Department KU7MOCSTA401			3						

S7 - List of Discipline Specific Electives (DSE) (POOL C)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7E.1	400	KU7DSESTA409	Applied Regression Analysis	4	3	2	1	50	50	100
7E.2	400	KU7DSESTA410	Data Visualisation and Analysis Using Python	4	3	2	1	50	50	100
7E.3	400	KU7DSESTA411	Demographic Studies	4	3	2	1	50	50	100
7E.4	400	KU7DSESTA412	Bioistatistical Computing Using R	4	1	6	1	50	50	100
7E.5	400	KU7DSESTA413	Biostatistical Computing Using SPSS	4	1	6	1	50	50	100

Semester VIII

No	level	Course Code	Course Name		C	Hrs./wk.			Assessment Weightage (%)		
						L	P	Tt	ESA	CE	T
8.1a	400	KU8DSCSTA401	Advanced Probability Theory		4	4	-	1	50	50	100
8.1b	400	KU8DSCSTA402	Survival Analysis		4	3	1	1	50	50	100
8.2	400	KU8RPHSTA401	Research/ Internship		12	24			50	50	100
OR											
8E.x	400	CODE FROM **POOL D**	DSE -1	From **POOL D**	4	3	2		50	50	100
8E.x	400		DSE-2		4	3	2		50	50	100
8E.x	400		DSE-3		4	3	2		50	50	100
8M	MOOC / Online course Approved by Department KU8MOCSTA402				3				--	--	--

S8 - List of Discipline Specific Electives (DSE) (POOL D)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
8E.1	400	KU8DSESTA404	Multivariate Analysis	4	3	2	1	50	50	100
8E.2	400	KU8DSESTA405	Statistical Analysis of Clinical Trials	4	3	2	1	50	50	100
8E.3	400	KU8DSESTA406	Reliability Modelling	4	3	2	1	50	50	100
8E.4	400	KU8DSESTA407	Advanced Bayesian Computing with R	4	3	2	1	50	50	100
8E.5	400	KU8DSESTA408	Generalized Linear Models	4	3	2	1	50	50	100
8E.6	400	KU8DSESTA409	Analysis of Longitudinal Data	4	3	1	1	50	50	100
8E.7	400	KU8DSESTA410	Applied Regression Analysis for Biostatistics	4	3	1	1	50	50	100
8E.8	400	KU8DSESTA411	Statistical Epidemiology	4	3	1	1	50	50	100
8E.9	400	KU8DSESTA412	Statistical Ecology and Genetics	4	3	1	1	50	50	100
8E.10	400	KU8DSESTA413	Applied Multivariate Analysis	4	3	1	1	50	50	100

Semester IX

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
9.1	500	KU09DSCSTA501	Advanced Sampling Theory	4	3	1	1	50	50	100
9.2	500	KU09DSCSTA502	Stochastic Processes	4	3	1	1	50	50	100
9.3	500	KU09DSCSTA503	Statistical Simulation Techniques	4	3	1	1	50	50	100
9.4	500	KU09DSCSTA504	Advanced Multivariate Analysis	4	3	1	1	50	50	100
9.5	500	KU09DSCSTA505	Advanced Design of Experiments	4	3	1	1	50	50	100
9.6	500	KU09DSCSTA506	Generalized Linear Models for Biostatistics	4	3	1	1	50	50	100
9.7	500	KU09DSCSTA507	Advanced Time Series Analysis	4	3	1	1	50	50	100

Semester X

<table>
<tr><th rowspan="2">No</th><th rowspan="2">level</th><th rowspan="2">Course Code</th><th rowspan="2" colspan="2">Course Name</th><th rowspan="2">C</th><th colspan="3">Hrs./wk.</th><th colspan="3">Assessment Weightage (%)</th></tr>
<tr><th>L</th><th>P</th><th>Tt</th><th>ESA</th><th>CE</th><th>T</th></tr>
<tr><td>10.1</td><td>500</td><td>KU10CIPSTA501</td><td colspan="2">Research/ Internship</td><td>20</td><td colspan="2">36</td><td></td><td>50</td><td>50</td><td>100</td></tr>
<tr><td colspan="12">OR</td></tr>
<tr><td>10E.1</td><td>500</td><td rowspan="5">CODE FROM
POOL E</td><td>DSE -1</td><td rowspan="5">From
POOL E</td><td>4</td><td>3</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
<tr><td>10E.2</td><td>500</td><td>DSE-2</td><td>4</td><td>3</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
<tr><td>10E.3</td><td>500</td><td>DSE-3</td><td>4</td><td>3</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
<tr><td>10E.4</td><td>500</td><td>DSE-4</td><td>4</td><td>3</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
<tr><td>10E.5</td><td>500</td><td>DSE-5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
</table>

S10 - List of Discipline Specific Electives (DSE) (POOL E)

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
10E.1	500	KU10DSESTA501	Operations Research	4	3	1	1	50	50	100
10E.2	500	KU10DSESTA502	Non-parametric Inference	4	3	1	1	50	50	100
10E.3	500	KU10DSESTA503	Analysis of Financial Time Series	4	3	1	1	50	50	100
10E.4	500	KU10DSESTA504	Categorical Data Analysis	4	3	1	1	50	50	100
10E.5	500	KU10DSESTA505	Mixture Regression Models	4	3	1	1	50	50	100
10E.6	500	KU10DSESTA506	Analysis of Discrete and Longitudinal Data	4	3	1	1	50	50	100
10E.7	500	KU10DSESTA507	Advanced Queuing Theory	4	3	1	1	50	50	100
10E.8	500	KU10DSESTA508	Health Economics	4	3	1	1	50	50	100
10E.9	500	KU10DSESTA509	Life Contingencies	4	3	1	1	50	50	100

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4SE.1	200	KU4SECSTA201	Data Analysis using Excel	3	2	1	0	50	50	100
4SE.2	200	KU4SECSTA202	Data Analysis using SPSS	3	2	1	0	50	50	100

Semester 5 SEC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5SE.1	300	KU5SECSTA301	Basic Statistics using R	3	2	1	0	50	50	100
5SE.2	300	KU5SECSTA302	Statistical Data Visualization and Graphics	3	2	1	0	50	50	100

Semester 6 SEC POOL 3										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6SE.1	300	KU6SECSTA303	Statistical Reporting and Interpretation	3	2	1	0	50	50	100
6SE.2	300	KU6SECSTA304	Data Analysis using SAS	3	2	1	0	50	50	100

MULTI DISCIPLINARY COURSES

Semester 1 MDC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1MD.1	100	KU1MDCSTA101	Basic Statistics	3	2	1	1	50	50	100

Semester 2 MDC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
2MD.1	200	KU2MDCSTA201	Correlation and Regression Analysis	3	2	1	1	50	50	100

Semester 3 MDC POOL 3										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
3MD.1	300	KU3MDCSTA202	Applied Statistical Inference	3	2	1	1	50	50	100

STATISTICAL SCIENCE PATHWAYS

BSc (Statistics)
BSc (Hons)/ BSc (Hons. With Research) (Statistics)
BSc (Hons)/ BSc (Hons. With Research) (Biostatistics)
MSc (Statistics)
MSc (Biostatistics)

Model Course Structure

BSc (Statistics) – 3rd Year Exit

Model Course Distribution for the BSc (Statistics) Programme with effect from 2024- 25 Onwards (3rd Year Exit)										
Sem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total Courses**	**Total Credits**
	Discipline Specific		**MDC**							
#	**Core Courses (DSC)**	**Electives (DSE)**	**IDE/MDC /Open**	**AEC 3 Credits**	**SEC 3 Credits**	**VAC**	**MOOC / Online**	**Internship**		
1	KU1DSCSTA101 And 2 Courses from other department or discipline 4 credit each		MDC -1	AEC-1 AEC-2					**6**	**21**
	12 Credits	**0**	**3**	**6**						
2	KU2DSCSTA102 KU2DSCSTA103 And 2 Courses from other department or discipline 4 credit each		MDC -2	AEC-3					**6**	**22**
	16 Credits	0	3	**3**						
3	KU3DSCSTA201 KU3DSCSTA202 KU3DSCSTA203 KU3DSCSTA204		MDC-3			VAC-1			**6**	**22**
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCSTA205 KU4DSCSTA206 KU4DSCSTA207 KU4DSCSTA208				SEC-1	**VAC-2**			6	22
	12	**4**			3	**3**				
5	KU5DSCSTA301 KU5DSCSTA302	**Elective POOL A Any One**			SEC-2					

	KU5DSCSTA303 KU5DSCSTA304	KU5DSESTA305 KU5DSESTA306							6	23
	16	**4**			3					
6	KU6DSCSTA307 KU6DSCSTA308 KU6DSCSTA309	**Elective POOL B** **Any One** KU6DSESTA310 KU6DSESTA311 KU6DSESTA312			SEC-3			KU6INTSTA301	6	23
	12	**4**			3			4		
	Total Credit earned									**133**

Model Course Structure

BSc Hons. (Statistics) / BSc Hons. with Research (Statistics) – 4th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/ Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCSTA101 And 2 Courses from other department or discipline 4 credit each		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	**0**	3	6						
2	KU2DSCSTA102 KU2DSCSTA103 And 2 Courses from other department or discipline 4 credit each		MDC -2	AEC-3					6	22
	16 Credits	0	3	**3**						
3	KU3DSCSTA201 KU3DSCSTA202 KU3DSCSTA203 KU3DSCSTA204		MDC-3			VAC-1			6	22
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCSTA205 KU4DSCSTA206 KU4DSCSTA207 KU4DSCSTA208				SEC-1	VAC-2			6	22
	12	**4**			3	**3**				

5	KU5DSCSTA301 KU5DSCSTA302 KU5DSCSTA303 KU5DSCSTA304	**Elective POOL A** **Any One** KU5DSESTA305 KU5DSESTA306			SEC-2				**6**	**23**
	16	**4**			**3**					
6	KU6DSCSTA307 KU6DSCSTA308 KU6DSCSTA309	**Elective POOL B** **Any One** KU6DSESTA310 KU6DSESTA311 KU6DSESTA312			SEC-3			KU6INTSTA301	6	23
	12	**4**			3			4		
7	KU7DSCSTA401 KU7DSCSTA402 KU7DSCSTA403 KU7DSCSTA404	**Elective Pool C** **Any One** KU7DSESTA409 KU7DSESTA410 KU7DSESTA411					**MOOC-1** KU7MOCSTA401		6	24
	16	**4**					**4**			
8	KU8DSCSTA401	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) **Any three** KU8DSESTA404 KU8DSESTA405 KU8DSESTA406 KU8DSESTA407 KU8DSESTA408 KU8DSESTA409					**MOOC-2** KU8MOCSTA402	KU8RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

Model Course Structure

BSc Hons. (Biostatistics) / BSc Hons. with Research (Biostatistics) – 4th Year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCSTA101 And 2 Courses from other department or discipline 4 credit each		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCSTA102 KU2DSCSTA103 And 2 Courses from other department or discipline 4 credit each		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCSTA201 KU3DSCSTA202 KU3DSCSTA203 KU3DSCSTA204		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU4DSCSTA205 KU4DSCSTA206 KU4DSCSTA207 KU4DSCSTA208				SEC-1	VAC-2				
	12	4			3	3			6	22

5	KU5DSCSTA301 KU5DSCSTA302 KU5DSCSTA303 KU5DSCSTA304	**Elective POOL A** **Any One** KU5DSESTA305 KU5DSESTA306			SEC-2				6	23
	16	**4**			3					
6	KU6DSCSTA307 KU6DSCSTA308 KU6DSCSTA309	**Elective POOL B** **Any One** KU6DSESTA310 KU6DSESTA311 KU6DSESTA312			SEC-3			KU6INTSTA301	6	23
	12	**4**			3			4		
7	KU7DSESTA405 KU7DSESTA406 KU7DSESTA407 KU7DSESTA408	**Elective Pool F** **Any One** KU7DSESTA410 KU7DSESTA411 KU7DSESTA412 KU7DSESTA413					**MOOC-1** KU7MOCSTA401		6	24
	16	**4**					**4**			
8	KU8DSCSTA402	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) KU8DSESTA408 KU8DSESTA409 KU8DSESTA410 KU8DSESTA411 KU8DSESTA412 KU8DSESTA413					**MOOC-2** KU8MOCSTA402	KU8DSCSTA403 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

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Model Course Structure-

MSc (Statistics)– 5th Year Exit

SEM	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		**MDC**							
#	**Core Courses (DSC)**	**Electives (DSE)**	**IDE/MDC /Open**	**AEC 3 Credits**	**SEC 3 Credits**	**VAC**	**MOOC / Online**	**Internship**		
1	KU1DSCSTA101 And 2 Courses from other department or discipline 4 credit each		MDC -1	AEC-1 AEC-2					**6**	**21**
	12 Credits	**0**	**3**	**6**						
2	KU2DSCSTA102 KU2DSCSTA103 And 2 Courses from other department or discipline 4 credit each		MDC -2	AEC-3						
	16 Credits	0	3	**3**					**6**	**22**
3	KU3DSCSTA201 KU3DSCSTA202 KU3DSCSTA203 KU3DSCSTA204		MDC-3			VAC-1			**6**	**22**
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCSTA205 KU4DSCSTA206 KU4DSCSTA207 KU4DSCSTA208				SEC-1	VAC-2				
	12	**4**			3	**3**			6	**22**
5	KU5DSCSTA301 KU5DSCSTA302 KU5DSCSTA303 KU5DSCSTA304	**Elective POOL A** **Any One** KU5DSESTA305 KU5DSESTA306			SEC-2					
	16	**4**			3				6	**23**
6	KU6DSCSTA307 KU6DSCSTA308	**Elective POOL B** **Any One**			SEC-3			Intenship KU6INTSTA301		

	KU6DSCSTA309	KU6DSESTA310 KU6DSESTA311 KU6DSESTA312							6	
	12	**4**			3			4		**23**
7	KU7DSCSTA401 KU7DSCSTA402 KU7DSCSTA403 KU7DSCSTA404	**Elective Pool C** **Any One** KU7DSESTA409 KU7DSESTA410 KU7DSESTA411					MOOC-1 KU7MOCSTA401		6	**24**
	16	**4**					**4**			
8	KU8DSCSTA401	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) **Any three** KU8DSESTA404 KU8DSESTA405 KU8DSESTA406 KU8DSESTA407 KU8DSESTA408 KU8DSESTA409					MOOC-2 KU8MOCSTA402	KU8RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course	6	**20**
	4	**12**					**4**	**12**		
9	KU09DSCSTA501 KU09DSCSTA502 KU09DSCSTA503 KU09DSCSTA504 KU09DSCSTA505 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU09CIPSTA501 KU09MOCSTA501			**20**
	20 /16/12						**0/4/8**			
10	KU10CIPSTA501 **Research (20C)** **OR**									**20**
		5 DSE Courses from Pool E **Any Five** KU10DSESTA501 KU10DSESTA502 KU10DSESTA503 KU10DSESTA504 KU10DSESTA505 KU10DSESTA506 KU10DSESTA507								
		20								
	Total Credit earned									**217**

Model Course Structure, MSc(Biostatistics) 5th Year Exit

#	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCSTA101 And 2 Courses from other department or discipline 4 credit each		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	**0**	**3**	**6**						
2	KU2DSCSTA102 KU2DSCSTA103 And 2 Courses from other department or discipline 4 credit each		MDC -2	AEC-3					6	22
	16 Credits	0	3	**3**						
3	KU3DSCSTA201 KU3DSCSTA202 KU3DSCSTA203 KU3DSCSTA204		MDC-3			VAC-1			6	22
	16 Credits		**3 Credits**			**3 Credit**				
4	KU4DSCSTA205 KU4DSCSTA206 KU4DSCSTA207 KU4DSCSTA208				SEC-1	**VAC-2**				
	12	**4**			3	**3**			6	22
5	KU5DSCSTA301 KU5DSCSTA302 KU5DSCSTA303 KU5DSCSTA304	**Elective POOL A Any One** KU5DSESTA305 KU5DSESTA306			SEC-2					
	16	**4**			3				6	23
6	KU6DSCSTA307 KU6DSCSTA308 KU6DSCSTA309	**Elective POOL B Any One** KU6DSESTA310			SEC-3			Intenship KU6INTSTA301	6	

		KU6DSESTA311 KU6DSESTA312								23
	12	**4**			3			4		
7	KU7DSESTA405 KU7DSESTA406 KU7DSESTA407 KU7DSESTA408	**Elective Pool C** **Any One** KU7DSESTA410 KU7DSESTA411 KU7DSESTA412 KU7DSESTA413					MOOC-1 KU7MOCSTA401		6	24
	16	**4**					**4**			
8	KU8DSCSTA402	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) KU8DSESTA408 KU8DSESTA409 KU8DSESTA410 KU8DSESTA411 KU8DSESTA412 KU8DSESTA413					MOOC-2 KU8MOCSTA402	KU8RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
9	KU09DSCSTA502 KU09DSCSTA503 KU09DSCSTA505 KU09DSCSTA506 KU09DSCSTA507 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU09CIPSTA501 KU09MOCSTA501			20
	20/16/12						**0/4/8**			20
10	**Research (20Credit)** KU10CIPSTA501 **OR**									
		5 DSE Courses from Pool E **Any five** KU10DSESTA501 KU10DSESTA502 KU10DSESTA504 KU10DSESTA505 KU10DSESTA506 KU10DSESTA508 KU10DSESTA509								20
		20								
	Total Credit earned									217

MATHEMATICAL SCIENCE COURSES

Semester I

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
1.1	100	KU1DSCMAT101	LOGIC AND SET THEORY	4	4	0	1	50	50	100

Semester II

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
2.1	100	KU2DSCMAT101	INTRODUCTION TO MATRIX THEORY , PARAMETRIC EQUATIONS AND POLAR CO - ORDINATES	4	4	0	1	50	50	100
2.2	100	KU2DSCMAT102	CALCULUS I	4	4	0	1	50	50	100

Semester III

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3.1	200	KU3DSCMAT201	CALCULUS II	4	4	0	1	50	50	100
3.2	200	KU3DSCMAT202	DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100
3.3	200	KU3DSCMAT203	NUMBER THEORY	4	4	0	1	50	50	100
3.4	200	KU3DSCMAT204	NUMERICAL ANALYSIS	4	4	0	1	50	50	100

Semester IV

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4.1	200	KU4DSCMAT201	CALCULUS III	4	4	0	1	50	50	100
4.2	200	KU4DSCMAT202	INTRODUCTION TO GRAPH THEORY	4	4	0	1	50	50	100
4.3	200	KU4DSCMAT203	LINEAR ALGEBRA I	4	4	0	1	50	50	100
4.4	200	KU4DSCMAT204	VECTOR VALUED FUNCTIONS AND MULTIVARIABLE CALCULUS	4	4	0	1	50	50	100

Semester V

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5.1	300	KU5DSCMAT301	ALGEBRA I	4	4	0	1	50	50	100
5.2	300	KU5DSCMAT302	COMPLEX ANALYSIS I	4	4	0	1	50	50	100
5.3	300	KU5DSCMAT303	LINEAR ALGEBRA II	4	4	0	1	50	50	100
5.4	300	KU5DSCMAT304	REAL ANALYSIS I	4	4	0	1	50	50	100
5E.x	Elective -DSE (POOL D)			4	POOL D			50	50	100

S5 - List of Discipline Specific Electives (DSE) (POOL D)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5E.1	300	KU5DSEMAT301	INTRODUCTION TO GEOMETRY	4	4	0	1	50	50	100
5E.2	300	KU5DSEMAT302	MULTIPLE INTEGRALS AND VECTOR INTEGRATION	4	4	0	1	50	50	100
5E.3	300	KU5DSEMAT303	THEORY OF EQUATIONS	4	4	0	1	50	50	100

Semester VI

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6.1	300	KU6DSCMAT301	ALGEBRA II	4	4	0	1	50	50	100
6.2	300	KU6DSCMAT302	COMPLEX ANALYSIS II	4	4	0	1	50	50	100
6.3	300	KU6DSCMAT303	REAL ANALYSIS II	4	4	0	1	50	50	100
6.4	Elective – DSE (Pool E)							50	50	100
6.5	300	KU6INTMAT301	INTERNSHIP / MINOR PROJECT	4	0	0	5	50	50	100

S6 - List of Discipline Specific Electives (DSE) (POOL E)

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6E.1	300	KU6DSEMAT301	LINEAR PROGRAMMING	4	4	0	1	50	50	100
6E.2	300	KU6DSEMAT302	TOPOLOGY OF METRIC SPACES	4	4	0	1	50	50	100
6E.3	300	KU6DSEMAT303	CRYPTOGRAPHY	4	4	0	1	50	50	100

Semester VII

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7.1	400	KU7DSCMAT401	ALGEBRA III	4	4	0	1	50	50	100
7.2	400	KU7DSCMAT402	LINEAR ALGEBRA II	4	4	0	1	50	50	100
7.3	400	KU7DSCMAT403	REAL ANALYSIS-III	4	4	0	1	50	50	100
7.4	400	KU7DSCMAT404	TOPOLOGY	4	4	0	1	50	50	100
7E.X	Elective -DSE (POOL F)			4	POOL F			50	50	100
7M	MOOC / Online course Approved by Department KU7MOCCMAT401			4						

S7 - List of Discipline Specific Electives (DSE) (POOL F)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7E.1	400	KU7DSEMAT401	ALGEBRAIC NUMBER THEORY	4	3	2	1	50	50	100
7E.2	400	KU7DSEMAT402	ANALYTIC NUMBER THEORY	4	3	2	1	50	50	100
7E.3	400	KU7DSEMAT403	NUMBER THEORY	4	3	2	1	50	50	100

Semester VIII

No	level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
8.1	400	Elective – DSE (Pool G)		4				50	50	100
8.2	MOOC / Online course Approved by Department KU8MOCCMAT401			4				-	-	-
8.3	400	KU8RPHMAT401	RESEARCH/ INTERNSHIP	12	24			50	50	100
OR										
8.4	400	KU8DSCMAT401	FU CTION L ANA LYS50S I 50	540	4	0	1	50	50	100
8.5	400	KU8DSCMAT402	MEASURE AND INTEGRATION	4	4	0	1	50	50	100
8.6	400	KU8DSCMAT403	ORDINARY DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100

S8 - List of Discipline Specific Electives (DSE) (POOL G)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
8E.1	400	KU8DSEMAT401	CODING THEORY	4	4	0	1	50	50	100
8E.2	400	KU8DSEMAT402	REPRESENTATION THEORY OF FINITE GROUPS	4	4	0	1	50	50	100
8E.3	400	KU8DSEMAT403	FUZZY MATHEMATICS	4	4	0	1	50	50	100

Semester IX

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
9.1	500	KU9DSCMAT501	ALGEBRA IV	4	4	0	1	50	50	100
9.2	500	KU9DSCMAT502	COMPLEX ANALYSIS III	4	4	0	1	50	50	100
9.3	500	KU9DSCMAT503	FUNCTIONAL ANALYSIS II	4	4	0	1	50	50	100
9.4	500	KU9DSCMAT504	FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAL GEOMETRY	4	4	0	1	50	50	100
9.5	500	KU9DSCMAT505	PARTIAL DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100

Semester X

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
10.1	500	KU10DSRMAT501	RESEARCH AT NATIONAL LEVEL INSTITUTE	20	36		1	50	50	100
OR										
10.2	500	KU10DSCMAT501	ADVANCED TOPICS IN ANALYSIS	4	4	0	1	50	50	100
10.3	500	KU10DSCMAT502	ALGEBRAIC TOPOLOGY	4	4	0	1	50	50	100
10.4	500	KU10DSCMAT503	HARMONIC ANALYSIS	4	4	0	1	50	50	100
10.5	500	KU10DSCMAT504	OPERATOR ALGEBRAS	4	4	0	1	50	50	100
10.6	500	KU10DSCMAT505	INTRODUCTION TO LIE ALGEBRAS	4	4	0	1	50	50	100
10.7	500	KU10DSCMAT506	COMMUTATIVE ALGEBRA	4	4	0	1	50	50	100
10.8	500	KU10DMPMAT501 / KU10MOOCMAT501	MINOR PROJECT/ MOOC COURSE	4	-	-	-	50	50	100

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4SE.1	200	KU4SECMAT201	BASIC COURSE IN LATEX	3	2	2	0	50	50	100

MULTI DISCIPLINARY COURSES

Semester 1 MDC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1MD.1	100	KU1MDCMAT101	ELEMENTARY MATHEMATICS -1	3	3	0	1	50	50	100
1MD.2	100	KU2MDCMAT101	ELEMENTARY MATHEMATICS -2	3	3	0	1	50	50	100

MATHEMATICAL SCIENCE PATHWAYS

BSc (Mathematics)
BSc (Hons)/ BSc (Hons. With Research) (Mathematics)
MSc (Mathematics)

Model Course Structure

BSc (Mathematics) – 3rd Year Exit

Model Course Distribution for the BSc (Mathematics) Programme with effect from 2024- 25 Onwards (3rd Year Exit)										
	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC /Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCMAT101 And 2 Courses from another department / discipline		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCMAT101 KU2DSCMAT102 And 2 Courses from another department / discipline		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCMAT201 KU3DSCMAT202 KU3DSCMAT203 KU3DSCMAT204		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU4DSCMAT201 KU4DSCMAT202 KU4DSCMAT203 KU4DSCMAT204				SEC-1	VAC-2			6	22
	16	0			3	3				

5	KU5DSCMAT301 KU5DSCMAT302 KU5DSCMAT303 KU5DSCMAT304	**Elective POOL D Any One** KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303			**SEC-2**				**6**	**23**
	16	**4**			**3**					
6	KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303	**Elective POOL E Any One** KU6DSEMAT301 KU6DSEMAT302 KU6DSEMAT303			**SEC-3**			KU6INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
	Total Credit earned									**133**

Model Course Structure

BSc Hons. (Mathematics) / BSc Hons. with Research (Mathematics) – 4th Year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCMAT101 And 2 course from another department		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCMAT101 KU2DSCMAT102 and 2 courses from another department		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCMAT201 KU3DSCMAT202 KU3DSCMAT203 KU3DSCMAT204		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credits				
4	KU4DSCMAT201 KU4DSCMAT202 KU4DSCMAT203 KU4DSCMAT204				SEC-1	VAC-2				

	12	4			3	3			6	22
5	KU5DSCMAT301 KU5DSCMAT302 KU5DSCMAT303 KU5DSCMAT304	**Elective POOL D Any One** KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303			**SEC-2**				**6**	**23**
	16	**4**			**3**					
6	KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303	**Elective POOL E Any One** KU6DSEMAT301 KU6DSEMAT302 KU6DSEMAT303			**SEC-3**			KU6INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
7	KU7DSCMAT401 KU7DSCMAT402 KU7DSCMAT403 KU7DSCMAT404	**Elective Pool F Any One** KU7DSEMAT401 KU7DSEMAT402 KU7DSEMAT403					**MOOC-1** KU7MOCCMAT 401		**6**	**24**
	16	**4**					**4**			
8	KU8DSCMAT401 KU8DSCMAT402 KU8DSCMAT403 For BSc. Hons – in lieu of Research (12C)	Elective – DSE (Pool G)					**MOOC-2** KU8MOCCMAT401	KU8RPHMAT401 **Research** for BSc Hons with Research – in lieu of 3 DSC courses		**20**
	4	**12**					**4**	12		
	Total Credit earned									**177**

Model Course Structure

MSc (Mathematics) – 5th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU1DSCMAT101 2 courses from another department		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU2DSCMAT101 KU2DSCMAT102 And 2 courses from another department		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU3DSCMAT201 KU3DSCMAT202 KU3DSCMAT203 KU3DSCMAT204		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credits				
4	KU4DSCMAT201 KU4DSCMAT202 KU4DSCMAT203 KU4DSCMAT204				SEC-1	VAC-2				
	12	4			3	3			6	22
	KU5DSCMAT301	Elective POOL D			SEC-2					

5	KU5DSCMAT302 KU5DSCMAT303 KU5DSCMAT304	**Any One** KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303							**6**	**23**
	16	**4**			**3**					
6	KU5DSEMAT301 KU5DSEMAT302 KU5DSEMAT303	**Elective POOL E** **Any One** KU6DSEMAT301 KU6DSEMAT302 KU6DSEMAT303			**SEC-3**			KU6INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
7	KU7DSCMAT401 KU7DSCMAT402 KU7DSCMAT403 KU7DSCMAT404	**Elective Pool F** **Any One** KU7DSEMAT401 KU7DSEMAT402 KU7DSEMAT403					**MOOC-1** KU7MOCCMAT 401		**6**	**24**
	16	**4**					**4**			
8	KU8DSCMAT401 KU8DSCMAT402 KU8DSCMAT403 For BSc. Hons – in lieu of Research (12C)	Elective – DSE (Pool G)					**MOOC-2** KU8MOCCMAT401	KU8RPHMAT401 **Research** for BSc Hons with Research – in lieu of 3 DSC courses	**3/5**	**20**
	4	**12**					**4**	**12**		
9	KU9DSCMAT501 KU9DSCMAT502 KU9DSCMAT503 KU9DSCMAT504 KU9DSCMAT505						**One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU9MOCCMAT501		**5**	
	16/20						**0/4**		**20**	

10	**Research (20Credits) KU10DSRMAT501** **OR**								
	KU10DSCMAT501 KU10DSCMAT502 KU10DSCMAT503 KU10DSCMAT504 KU10DSCMAT505 KU10DSCMAT506 (Either Choose Five courses from this list or Choose 4 courses from this list and choose one from KU10DMPMAT501 / KU10MOOCMAT501)						MINOR PROJECT/ MOOC COURSE **KU10DMPMAT501 /** **KU10MOOCMAT501**	**5**	**20**
	20/20						**20/4**		
	Total Credit earned								**217**

COMPUTER SCIENCE /

COMPUTER SCIENCE AND ENGINEERING

COURSE DETAILS

COMPUTER SCIENCE/ COMPUTER SCIENCE AND ENGINEERING COURSE DETAILS

SEMESTER I

KU1DSCCSE101 PRINCIPLES OF PROGRAMMING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	DSC	100	KU1DSCCSE101	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE duration: 2 hours for theory and 3 hours for Lab**

Course Description: Computer Science is all about developing correct and efficient solutions for our day-to-day problems. The process of developing solutions is not centered on learning a programming language and doing coding straight away. Instead, a blueprint of the proposed solution should be outlined and tested for correctness. Once a proposed blueprint leads to a correct solution, it can be implemented using a suitable programming language. The objective of this course is to impart knowledge to the learner about building the blueprint of a solution. Learners are also exposed to implementing the solutions using the C programming language.

Course Objectives:

- To impart knowledge about various constructs for developing solutions

- To become familiar with using the various constructs to develop solutions
- To compare and contrast various constructs for solution development for selection
- To compare and contrast various constructs for solution development for iteration
- To implement solutions using C programming language

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Illustrate the foundations of developing solutions using flowcharts and algorithms
CO2	Develop solutions using various selection constructs and implement them in the C programming language
CO3	Develop solutions using various iteration constructs and implement them in the C programming language
CO4	Understand advanced concepts in direct memory handling, file handling and functions.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Problem-Solving: Preparing Solutions using Flowcharts: Conventions - Structure - Symbols. Preparing Solutions using Algorithms - Conventions - Top-Down and bottom-up approach. **Program:** Characteristics - Modular Approach - Style - Documentation and Maintenance - Compilers and Interpreters - Preparing, Running and Debugging Programs - Types of Errors. Fundamentals of C Language: Evolution and Features - Program Structure - Elements - Constructs. Character Set, Tokens, Keywords, Identifier. Data Types, Constants, Symbolic Constants, Variables, Data Input and Output, Statements - Assignment statements. Operators in C: arithmetic, relational, logical, assignment, auto increment, auto decrement, conditional, comma operators. Precedence of operators - expressions – evaluation of expressions, type conversion in expressions – precedence and associativity. (**15 hours)**

Module 2: Selection Constructs: Simple if - if else - if else if ladder - switch. Branching statements: break, goto. Case study: Developing solutions (flowcharts and algorithms) for problems using various selection constructs - Comparative Study of various Selection Constructs - Converting a solution using one selection construct with other selection constructs. (20 Hours)

Module 3: Iteration Constructs: Top Tested Vs Bottom Tested - while - for - do while - Nesting of loops - skipping breaking loops. Arrays - 1D and 2D, 3 D - Case study: Developing solutions (flowcharts and algorithms) for problems using various iteration constructs - Comparative Study of various iteration constructs - Converting a solution using one iteration construct with other iteration constructs. Functions and function calling mechanisms. **(20 hours)**

Module 4 : Advanced concepts in C: Concepts of memory allocation for variables- Direct memory accessing - Pointers- pointer arithmetics- structures- files and file operations- preprocessor directives- preparing customized header files. **(25 hours)**

Module X:

C programing for embedded systems: concepts of embedded systems - microcontrollers- basic programing with microcontroller. (10 Hours)

Core Compulsory Readings

1. J.B Dixit, Computer Fundamentals and Programming in C, Firewall Media
2. Anil Bikas Chaudhuri, The Art Of Programming Through Flowcharts Algorithms, Laxmi Publications, New Delhi.
3. Maureen Spraknle and Jim Hubbard, Problem Solving and Programming Concepts, Pearson
4. E Balagruswamy, Programming in ANSI C, TMH, 5th Edition

Core Compulsory Readings

1. R G Dromey, How to Solve by Computer, Pearson Education, 5th Edition
2. Brian W. Kernighan and Dennis M. Ritchie, C Programming Language, PHI
3. Kanetkar, Let Us C, BPB Publications, 8th Edition

TEACHING LEARNING STRATEGIES

- Lecturing, case study/mini projects, Team Learning, presenting seminars on selected topics, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Video tutorial

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions

1. Define algorithms ?
2. Discuss various characteristics of Algorithms ?
3. Explain flowchart and it symbols?
4. Draw flowcharts swapping two number with using an additional variable and without using additional variable
5. Write a program to illustrate the use of if-else statement
6. Explain nested-if statement
7. Compare between if-else and else-if ladder
8. Explain various methods for iteration
9. Explain switch case statement
10. Write a program to generate the series 1, 2, 4, 7, 11, 16……..
11. What is function and how function is called
12. What is direct memory accessing,
13. Define pointers
14. Explain various file operations.

Semester II

KU2DSCCSE102 FOUNDATIONS OF COMPUTER SCIENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	DSC	100	KU2DSCCSE102	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course provides an insight into the fundamentals of the basic topics of Computer Science such as Operating Systems, Database Management System, Computer Networks and Web Design. Course covers the essentials of all these diverse areas of Computer Science to provide a fundamental understanding about them to the students. Laboratory components are added in each module to provide a practical exposure to the learners.

Course Objectives:

- To understand the basics of Operating System
- To understand the basics of Database Management System
- To understand the basics of Computer Networks
- To understand the basics of Web Design

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the the basics of Operating System
CO2	Illustrate various features of Database Management System
CO3	Explain the fundamentals of Computer Networks
CO4	Explain the basics of web design and design simple static websites

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Definition of Computer Science - Classifications of Computer - Basic Building Block of Computer - Vonn Nueman Concept - Computer Hardware and Software - Classification of Software. Operating Systems: Definition - Structure - Types - Functions. Features of Windows and Linux Operating Systems. Case Study: Basic shell commands in Linux: Introduction to Shell Commands - Basic Folders - File and Folder Management: listing files, viewing contents in files, creating and deleting folders, creating files - moving and copying files and/or folders, man pages, setting permissions on files/directories. listing users that are logged in, listing the current user on the shell, listing all the details of the current user on the shell, listing the path of the current folder, adding a user, listing users that are currently created in the system, displaying the currently running process, the Kernel name, the processor name, the details of the operating system, and the information about the primary and secondary memory installed in the device.

Module 2: Database Management System: Introduction - Definition of Database and Database Management System (DBMS) - Unstructured, Semi

Structured and Structured Data - Characteristics of DBMS - Advantages of DBMS - Components of DBMS - Database Users - Data Models and Schema - Three Schema architecture - Database Languages - Database Architectures and Classification. Case Study: Structured Query Language (SQL) - Types of Commands: DML - DDL - DCL. Table: Definition - Data Types - Primary Key - Foreign Key - Creation - Deletion - Modification - Updation. Constraints: NULL - NOT NULL - UNIQUE. Displaying Data from Tables: Select - Logical operators - WHERE - Pattern matching - ORDER BY.

Module 3: Computer Networks: Definition - Advantages - Components - Categories. Transmission Modes: Simplex, Half duplex, Full duplex. Topology: Definition, Characteristics, Advantages and Disadvantages of Mesh, Star, Bus, Ring. Transmission Media - Wired (Definition, Characteristics, Advantages and Disadvantages of Shielded and Unshielded Twisted Pair, Coaxial, Optical) - Wireless (Definition, Characteristics, Advantages and Disadvantages of Microwave, Radio Wave and Infrared). Overview of OSI and TCP/IP Models. Networking Devices: Hub, Switch, Repeater, Bridge, Router. IP Address: V4 and V6. Case Study of networking command: host, hostname, ping, ifconfig, ip, traceroute, tracepath, netstat, ss, dig.

Module 4: Fundamentals of WWW: Web Technology - Client Server Communication - DNS Server. Web Design using HTML: Static and Dynamic Web - Introduction to HTML5 - Anatomy of HTML document - Container Tags - Empty Tags - Element - Attributes. Creating HTML document - Fundamental Elements (<!DOCTYPE>, <head>, <title>, <body>) - View HTML document in Browsers. Text Formatting: <b>, <i>, <u>, <emp>, <mark>, <small>, <del>, <sub>, <sup> - Comments - Headings - Paragraphs - Alignments - Background and Text Colour Formatting. Inserting Images: image formats supported, src, alt, width, height, alignment, border. Adding Links: img, target, image as a link, link to email. Tables: Creation, Row, Columns, Borders, Size, Heading, Caption, Alignment. Lists: Ordered, Unordered, Description. Additional Formatting: address, marquee, font, favicon. Case Study: Design and development of static web pages using HTML.

Module X : History and Evolution of Computer as a Problem-Solving Tool - Evolution of Computer Science as a Branch of Science - Evolution of Computer Science as a Career Option - Evolution of OS - Evolution of DBMS - History and Evolution of Computer Networks - Design of websites with client-side script

Core Compulsory Readings

1. Computer Fundamentals by P.K Sinha
2. Linux in a Nutshell, Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, O'Reilly
3. Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
4. Introduction to Database Systems, CJ Date, Addison Wesley. 4. Database Management Systems Ramakrishnan McGraw Hill
5. Behrouz A. Forouzan, Data Communications and networking, Fourth Edition, McGraw Hill 2017
6. Wale Soyinka, Linux Administration A Beginner's Guide, Fifth Edition, TMH
7. HTML 5 Blackbook, Dreamtech Press, ISBN 987-93-5119-907-6, 2016 Edition.

Core Suggested Readings

1. An introduction to Digital Computer design by V. Rajaraman and T. Radhakrishnan
2. Computer fundamentals by B. Ram
3. Andrew S. Tanenbaum, Computer Networks, Fifth Edition, Prentice-Hall 2011
4. William Stallings, Data and Computer Communication, Tenth Edition,

Prentice-Hall 2014
5. Evi Nemeth , et al, Linux Administration Hand Book , PHI 2018
6. Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.
7. Jon Duckett, Web Programming with HTML, XHTML, CSS, Wrox Beginning.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to Section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to Test Outcomes

1. Explain Von Nueman Architecture
2. List the advantages of DBMS
3. Identify the layers in OSI Model
4. Explain the anatomy of HTML document
5. Differentiate between any two classes of computers
6. Prepare the SQL commands to create two sample tables with a foreign key relationship between them
7. Differentiate between switch and hub
8. Prepare short notes on creating links in HTML document
9. Explain the evolution of the computer as a problem-solving tool
10. Explain the concepts of the database management system
11. Explain OSI model
12. Illustrate various text formatting options in HTML

KU2DSCCSE103 ENGINEERING DESIGN AND PROTOTYPING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	DSC	100	KU2DSCWST103	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description

This course provides an in-depth exploration of prototyping techniques and materials used for prototyping and will help to effectively communicate the ideas through engineering drawings. The course will also investigate sustainable prototyping practices with a particular emphasis on wood and bamboo. This is a joint inter-disciplinary course offered by Department of wood science and Technology and Department of Information Technology.

Course Objectives

- To understand the characteristics of different materials used in prototyping.
- To clearly communicate concepts using engineering drawings.
- To understand how to use CAD tools to create cost-effective and efficient prototypes.
- To explore the possibilities of sustainable prototyping with wood and bamboo

- To become familiar with the contemporary technology utilised in prototypes

Course outcome

On completion of this course the student will be able to:

C01	Communicate design concepts using engineering drawings and visualization techniques
C02	Develop an understanding of different materials and manufacturing processes used in prototyping
C03	Choose the appropriate prototyping material and process for their product development.
C04	Acquire proficiency in variety of woodworking hand tools and power tools for developing prototypes
C05	Develop a strong emphasis on safety practices in prototyping with different materials

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1 Engineering drawing for prototyping

Engineering drawing, importance of Engineering drawing in prototyping and product development, relationships of Engineering drawing with artistic drawing and other types of drawing, viewing an engineering drawing sheet, methods of sheet folding, drawing instruments, and drawing standards.

Module 2 prototyping materials

Material selection in prototyping. Properties of common materials used in prototyping. Wood and Metal prototyping; Resins and plastic prototyping: Introduction to basic metal working techniques including cutting, drilling machining and welding. Sheet metal fabrication, Polymers commonly used in prototyping. Introduction to Fused deposition modelling, Steriolithography methods for polymer prototyping. Health and safety in an engineering workshop.

Module 3 Wood and Bamboo as a sustainable prototyping material

Introduction to Wood and Bamboo as a sustainable prototyping material. Engineered wood products-plywood, MDF, particle boards and their applications. Familiarization with carpentry tools and woodworking machines, Practicing the basic woodworking tools and power tools used for marking, sawing, planning, and boring, Constructing important joints for lengthening, widening, and framing joints.

Module 4 Digital Technologies in product design and prototyping

Familiarizing the use of CAD in product design, Applications of Internet of things (IoT) systems in prototyping. Application of CNC machining and 3D Printing technologies in prototyping using different materials. Laser cutting and engraving

Module X

Introduction to design thinking; Methods of Empathy building; Problem framing and ideation; Testing and iteration; Benefits of prototyping in design thinking; Application of design thinking and prototyping in various disciplines; Case studies highlighting ethical problems in prototyping processes.

Core Compulsory Readings

1. Bjarki Hallgrimsson (2023) Prototyping and model making for product design: Second edition; Hachette UK
2. Kollmann,(1968): Principles of Wood Science & Technology- Volume I - Solid Wood, Springer-Verlage publications, New York
3. Gebhardt, Andreas & Hötter, Jan-Steffen. (2016). Additive Manufacturing 3D Printing for Prototyping and Manufacturing. 10.1007/978-1-56990-583-8.

4. Yang, Li & Hsu, Keng & Baughman, Brian & Godfrey, Donald & Medina, Francisco & Menon, Mamballykalathil & Wiener, Soeren. (2017). Additive Manufacturing of Metals: The Technology, Materials, Design and Production. 10.1007/978-3-319-55128-9.

5. Miller,M.R. *et.al.,*(2004): Carpentary and Constructions(4th Edition) ,The Mc Graw-Hill Companies,United State of America.

6. Khurmi R.S. & Gupta, J.K. (1981), A Text Book of Workshop Technology (Manufacturing Processes), S.Chand & Company Ltd, New Delhi, India

7. Um, Dugan. (2018). Solid Modeling and Applications. 10.1007/978-3-319-74594-7.

Core Suggested Readings

1. Chua, Chee & Leong, Kah Fai & Lim, Chu. (2010). Rapid prototyping: Principles and applications, third edition. 10.1142/6665.

2. Liou, Frank. (2007). Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development. 10.1201/9780429029721.

3. Bordegoni, Monica & Rizzi, Caterina. (2011). Innovation in Product Design: From CAD to Virtual Prototyping.

4. Hoadley, R.B. (2000). Understanding Wood: A Craftsman's Guide to Wood Technology. The Taunton Press

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, workshop and lab sessions

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to Test Outcomes

1. How does the application of computer-aided design (CAD) software assist prototype processes in product development?
2. Discuss the importance of standardisation and conventions in engineering drawing and drafting practices.
3. Conduct drilling operation on wood using the given power tool
4. How does the choice of wood and bamboo as a prototyping material correspond with the sustainability aims in product development?
5. Discuss the diverse range of materials used in prototyping, ranging from traditional options like plastics and metals to innovative choices

KU2DSCCSE104 Basic Science and Applications

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	DSC	100	KU2DSCCSE104	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description

This course serves as a foundational exploration of key scientific principles and their practical applications across various fields. Through a combination of theoretical learning and hands-on applications, students will gain a solid understanding of fundamental concepts in physics, chemistry, and biology, along with their real-world implications and applications.

Course Objectives

- Foundational Understanding: Build a strong grasp of physics, chemistry, and biology basics.
- Practical Application: Apply scientific concepts to real-world scenarios.
- Critical Thinking: Enhance problem-solving skills through hands-on activities.
- Interdisciplinary Awareness: Recognize the interconnectedness of scientific disciplines.

Course outcome

On completion of this course the student will be able to:

C01	Acquire a comprehensive understanding of fundamental principles in physics, chemistry, and biology.
C02	Develop practical skills to apply scientific concepts in various contexts, fostering problem-solving abilities.
C03	Enhance critical thinking skills to analyze and evaluate scientific phenomena and their applications.
C04	Acquire proficiency in variety of woodworking hand tools and power tools for developing prototypes
C05	Gain an interdisciplinary perspective, recognizing the connections between scientific disciplines and their collective impact on society and technology.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1 : Physic for Information Technology

Introduction to Shanon's information theory, Formal theory of noise; shot noise, Johnson noise, 1/f noise, Information theory in the context of statistical mechanics and precision of general measurements. (20 hours)

Module 2 : Modes of information

Electromagnetic waves, waveguides, antennas, lasers, modulators, switches. Information with solid state devices: electronic materials, devices, and systems with exotic states (20 hours)

Module 3 : Chemistry for Information Technology

Definition and importance of molecular spectroscopy. Interaction of electromagnetic radiation with matter. - Introduction to different spectroscopic methods (UV-Vis, IR, NMR, Raman, EPR, etc.- Introduction to vibrational spectroscopy-Introduction to rotational spectroscopy-Microwave spectroscopy -Introduction to electronic spectroscopy-Introduction to magnetic resonance spectroscopy-Nuclear Magnetic Resonance (NMR).(20 hours)

Module 4 : Biology for Information Processing

Neurons: The Building Blocks of the Nervous System A. Introduction to Neurons 1. Structure and Function of Neurons 2. Types of Neurons (Sensory, Motor, Interneurons) B. Neuronal Communication 1. Action Potential and Neuronal Signaling 2. Synaptic Transmission C. Neurotransmitters and Their Role in Brain Function. Brain Processing of Information A. Brain Structure and Organization 1. Overview of Brain Regions and Functions 2. Hemispheric Specialization and

Lateralization B. Sensory Processing 1. Vision, Auditory, Olfactory, Gustatory, and Somatosensory Systems 2. Perception and Interpretation of Sensory Information C. Higher Cognitive Functions 1. Memory, Learning, and Plasticity 2. Emotion, Motivation, and Decision Making. (20 hours)

Module X :

DNA: The Blueprint of Life A. Molecular Structure of DNA 1. Double Helix Structure and Base Pairing 2. DNA Replication and Repair Mechanisms B. Gene Expression and Protein Synthesis 1. Transcription and Translation Processes 2. Regulation of Gene Expression (Transcription Factors, Epigenetics) C. Genetic Variation and Inheritance 1. Mendelian Genetics and Inheritance Patterns 2. Genetic Disorders and Genetic Counseling (10 hours)

Core Compulsory Readings

1. Physics of Information Technology" by Neil Gershenfeld.
2. Molicualr spectroscopy C.N Banwell
3. Medical physiology by guyton

Core Suggested Readings

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, workshop and lab sessions

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to Test Outcomes

1. What are the fundamental principles of Shannon's information theory and how do they contribute to understanding noise in information technology systems?
2. Explain the different types of noise encountered in information technology, such as shot noise, Johnson noise, and 1/f noise, and discuss their implications for system performance.
3. Describe the role of electromagnetic waves in information technology and discuss how they are utilized in devices such as antennas, lasers, and modulators.
4. How do solid-state devices, including electronic materials and systems with exotic states, contribute to the processing and transmission of information in modern technology?
5. Provide an overview of molecular spectroscopy and explain its importance in information technology. Discuss the interaction of electromagnetic radiation with matter in this context.
6. Compare and contrast different spectroscopic methods (e.g., UV-Vis, IR, NMR, Raman) and their applications in analyzing molecular structure and dynamics for information technology purposes.
7. What are neurons, and how do their structure and function contribute to the nervous system's ability to process and transmit information?

Semester III

KU3DSCCSE201 INTRODUCTION TO DATA STRUCTURE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours

1	DSC	200	KU3DSCCSE201	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description: This course helps the learners to understand the various data structures, their organization, and operations. The course is also intended to help the learners to assess the applicability of different data structures and associated algorithms for solving real-world problems which require minimum space and time complexities.

Course Objectives:

- To impart knowledge about various data structures, their representation, and applications.
- Acquire knowledge of various searching and sorting techniques
- To familiarize the design and analysis of linear data structure algorithms related to linked list, stack and queue.
- To familiarize the usage of non-linear data structures and its implementation.

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Familiarizes the need of data structure for organizing/storing data in a computer system effective manner.
CO2	Design and implement array data structure and its operations for solving real world problems.
CO3	To impart knowledge about data structures like linked list, stack, queue and its implementation.
CO4	Familiarization of selected non-linear data structure, its representation and applications in real world problem scenarios.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction: Elementary data organization, Data Structure definition, Data type vs. data structure, Linear and non-linear data structures, Data structure operations, Applications of data structures, algorithms, characteristics, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms. (15 hours)

Module 2: Arrays: Introduction, Linear arrays, Representation of linear array in memory, Traversal, Insertions, Deletion operations, Multidimensional arrays, Parallel arrays, sparse matrix. **Searching & Sorting:** Linear search vs Binary search, Selection Sort, Insertion Sort, Bubble sort, Quick Sort and Merge Sort. **Strings:** Representation, operations and pattern matching. **Recursion:** concept and implementation. (20 hours)

Module 3: Linked List: Introduction, Array vs. linked list, Representation of linked lists in memory, Traversal, Insertion, Deletion, Searching in a linked list, Header linked list, Circular linked list, Two-way linked list, Garbage collection, Applications of linked lists**. Stack:** Representation of stack using array and linked list, Primitive operation and implementation **Stacks applications:** conversion of infix to postfix expression, evaluation of expression. **Queues:** Representation of Queues as Linked List and array, Primitive Operations, Circular queue, Priority queue, Applications of queue. (25 hours)

Module 4: Non-linear data structure: Trees - Basic Terminology, representation, Binary Trees, Tree Representations using Array & Linked List, Basic operation on Binary tree, **Traversal of binary trees:-** In order, Preorder & post order, algorithms of tree traversal with and without recursion. Applications of Binary tree, Binary search tree. **Graphs:** Introduction to graphs, Definition, Terminology, Directed, Undirected & Weighted graph, Representation of graphs. **(25 hours)**

Module X : Polynomial representation with arrays and linked list, Parallel array, Implementation of sparse matrix, Implementation of recursion using stack, introduction to AVL tree and its implementation. Graph traversing algorithms. (10 hours)

Core Compulsory Readings

1. Seymour Lipschutz, "Data Structures", Tata McGraw- Hill Publishing Company Limited, Schaum's Outlines, New Delhi.
2. Yedidyan Langsam, Moshe J. Augenstein, and Aaron M. Tenenbaum,

"Data Structures Using C", Pearson Education., New Delhi.

Core Suggested Readings

1. Trembley, J.P. And Sorenson P.G., "An Introduction to Data Structures With Applications", Mcgraw- Hill International Student Edition, New York
2. Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, Universities Press, Fundamentals of Data Structures in C.
3. Samanta D., Classic Data Structures, Prentice Hall India.
4. Richard F. Gilberg, Behrouz A. Forouzan, Data Structures: A Pseudocode Approach with C, 2/e, Cengage Learning.

TEACHING LEARNING STRATEGIES

- **Lecturing, Demonstration, Digital Learning, Team Work**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion**

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

1. What is data structure?

2. What are the characteristics of an algorithm?

3. Differentiate between time and space complexity of an algorithm?

4. Explain the various techniques for designing an efficient algorithm.

5. Distinguish between linear and non-linear data structure?

6. Explain the different types of arrays and its operations.

7. What is bubble sort?

8. What is binary search?

9. What is recursion? Explain how it is implemented?

10. What is stack? Explain its basic operation.

11. Explain the applications of stack?

12. What is meant by FIFO?

13. What is meant by LIFO?

14. What are priority queues?

15. What is a linked list?

16. Explain the different operations on the linked list.

17. What is a doubly linked list?

18. Explain the applications of the queue.

19. What are the different types of lists? Explain the applications of each one.

20. What is BST?

21. Explain a quick sort algorithm.

22. What are the different tree traversing algorithms? Explain.

23. Explain selection sort algorithm?

24. Explain about different polish notations.

25. Compare and contrast selection sort and insertion algorithm with example

KU3DSCCSE202 OBJECT-ORIENTED PROGRAMMING USING C++

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	CORE	200	KU3DSCCSE202	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description:

This course provides an introduction to the principles and practices of object-oriented programming (OOP) using the C++ programming language. Students will learn fundamental concepts of OOP and how to apply them to develop software solutions using C++.

Course Objectives:

- Understand the principles of Object-Oriented Programming (OOP) using C++
- Master the syntax and semantics of the C++ programming language
- Gain proficiency in defining and utilizing classes and objects in C++
- Learn techniques for code reusability and flexibility through the use of templates and generic programming, along with mastering concepts

like interface classes, operator overloading, and friend functions

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamental principles of Object-Oriented Programming (OOP)
CO2	Gain a deep understanding of the concepts of inheritance, polymorphism, virtual functions.
CO3	Master the concept of interface classes and implementation inheritance and acquire proficiency in exception handling
CO4	Master the concept of file handling in C++ and learn the principles of file stream classes in the Standard Template Library (STL).

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Object-Oriented Programming with C++, Basics of Object-Oriented Programming (OOP), Variables, data types, and operators, Control flow statements (if-else, loops), Functions and parameter passing, Introduction to C++ programming language Classes and objects, Defining classes and objects in C++, Encapsulation and data hiding, Constructors and destructors. (15 hours)

Module 2: Inheritance and its types (single, multiple, multilevel, hierarchical), Polymorphism and its types (compile-time and runtime), Function overriding and virtual functions, Abstract classes and pure virtual functions, Dynamic binding and late binding. (20 hours)

Module 3: Interface classes and implementation inheritance. Templates and generic programming, Exception handling, Operator overloading, Friend functions and classes, Static members and member functions. (25 hours)

Module 4: File handling in C++ (reading from and writing to files), Error handling with exceptions, try-catch blocks and exception handling mechanisms, User-defined exception classes, File stream classes in the Standard Template Library (STL). (25 hours)

Module X (Teacher Specific):

Overview of the Standard Template Library (STL), Containers (vector, list, map, set, etc.), Algorithms (sorting, searching, etc.), Iterators and their usage, Smart pointers and memory management (10 hours)

Core Compulsory Readings

1. "The C++ Programming Language" by Bjarne Stroustrup
2. "Object-Oriented Programming with C++" by E Balagurusamy
3. "Programming: Principles and Practice Using C++" by Bjarne Stroustrup

Core Suggested Readings

1. "C++ Primer Plus" by Stephen Prata
2. "Starting Out with C++ from Control Structures to Objects" by Tony Gaddis

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

1. What is Object-Oriented Programming (OOP) and why is it important in software development?
2. Define a class in C++ and explain the role of objects. Provide an example of defining a class and creating objects.
3. Define inheritance and discuss its types in C++. Provide examples for each type.
4. Describe operator overloading in C++. Provide examples of overloaded operators.
5. What is user-defined exception classes? Provide examples of creating and using custom exception classes.

KU3DSCCSE203 ENGINEERING PHYSICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	DSC	200	KU3DSCCSE203	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: Engineering Physics covers fundamental concepts in mechanics, waves, modern physics, photonics, and new engineering materials. Topics include mechanics, waves and oscillations, modern physics theories, photonics principles, and new materials such as dielectrics, superconductors, nanomaterials, and smart materials. Students explore applications in engineering fields through theoretical understanding and practical applications.

Course Objectives:

- Provide a foundational understanding of mechanics, waves, modern physics, photonics, and engineering materials.

- Enable students to apply theoretical knowledge to solve engineering problems.
- Familiarize students with advanced photonics principles and their applications.
- Introduce emerging engineering materials and their significance in engineering applications.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Proficiency in mechanics, waves, modern physics, and photonics principles for engineering applications.
CO2	Ability to analyze and predict wave phenomena and optics behavior.
CO3	Understanding of modern physics theories and their applications.
CO4	Competence in applying photonics principles, including laser systems and optical fibers, in engineering contexts.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Mechanics: Orthogonal coordinate systems and frames of reference, conservative and non-conservative forces, work-energy theorem, potential energy and concept of equilibrium; Rotation about fixed axis, translational-rotational motion, vector nature of angular velocity, rigid body rotation and its applications. (15 hours)

Module 2: Waves and Oscillations & Wave Optics: Harmonic oscillator, damped and forced oscillations, resonance, coupled oscillations, -longitudinal and transverse waves, wave equation, plane waves, phase velocity, superposition wave packets and group velocity, two- and three-dimensional waves. Wave optics- Huygens' principle, superposition of waves –Theory of interference of light -Young's double slit experiment. Fresnel and Fraunhofer diffraction (20 hours)

Module 3: Modern Physics: Black body radiation-Planck's law – Energy distribution function, Wave – particle duality-de Broglie matter waves – Concept of wave function and its physical significance – Heisenberg's Uncertainity Principle – Schrodinger's wave equation – Time independent and Time dependent equations – Particle in a one-dimensional rigid box – tunneling (Qualitative). Hilbert space, observables, Dirac notation, principle of superposition, (25 hours)

Module 4: Photonics: Einstein's theory of matter radiation interaction and A and B coefficients; Properties of laser- spontaneous and stimulated emission, amplification of light by population inversion, different types of lasers: solid-state laser(Neodymium), gas lasers (CO2), applications –IR Thermography. Optical fibre- principle [TIR]-types-material, mode, refractive index-Fibre loss-Expression for acceptance angle and numerical aperture. Application-Communication. (25 hours)

Module X :

Dielectric materials: Definition – Dielectric Breakdown – Dielectric loss – Internal field – Claussius Mossotti relation. **Superconducting materials**: Introduction – Properties- Meissner effect – Type I & Type II superconductors – BCS theory- Applications. **Nanomaterials: Introduction** – Synthesis of nano materials – Top down and Bottom up approach- Ball milling- PVD method- Applications. Smart materials: Shape memory alloys-Biomaterials (properties and applications) (5 hours)

Core Compulsory Readings

1. D. Kleppner and R. J. Kolenkow, An introduction to Mechanics, Tata McGraw Hill, New Delhi, 2000. 2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, NY, 2007.
2. Frank S. Crawford, Berkeley Physics Course Vol 3: Waves and Oscillations, McGraw Hill, 1966.
3. Eyvind H. Wichmann, Berkeley Physics Course Vol 4: Quantum physics, McGraw Hill, 1971.

Core Suggested Readings

1. Optics by Subramaniam N & BrijLal, S Chand & Co. Pvt. Ltd., New Delhi, [unit 1]
2. Modern Physics by R Murugeshan, Kiruthiga, Sivaprasath S Chand [all units]
3. Quantum Mechanics by Sathyaprakash, Pragati Prakashan, Meerut. [unit 2]
4. Applied Engineering Physics – Rajendran & Marikani (Tata McGraw Hill) [unit 3,5] 2009
5. Engineering Physics – Bhattacharya, Bhaskaran – Oxford Publications [unit 2,3,5] 2012
6. Engineering Physics I & II – G.Senthilkumar, VRB publications [unit 2,3] 2012

7. Applied Physics for Engineers – K.Venkatramanan, R.Raja, M.Sundarrajan(Scitech) [3,5] 2014

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion**

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to Test Outcomes

1. How do conservative and non-conservative forces differ, and what role do they play in the work-energy theorem?
2. Explain the concept of rotational motion about a fixed axis and its applications in engineering.
3. Describe the characteristics of harmonic oscillators and their significance in wave phenomena.
4. How does Huygens' principle contribute to our understanding of wave optics, and what are its practical applications?
5. Discuss the significance of Planck's law in understanding black body radiation and its applications.
6. Explain the concept of wave-particle duality and its implications in modern physics theories.
7. What are the properties of laser systems, and how do they contribute to applications such as infrared thermography?
8. Describe the principles of optical fiber communication, including total internal reflection and numerical aperture.

KU3DSCCSE204 SCIENTIFIC COMPUTING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	DSC	200	KU3DSCCSE204	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course on Scientific Computing is designed to provide students with a comprehensive introduction to computational techniques used in various scientific disciplines. Students will gain practical knowledge of programming languages commonly used in scientific computing, numerical methods, data manipulation, and high-performance computing. The course will emphasize hands-on experience through programming exercises and projects, enabling students to apply the acquired skills to solve real-world scientific problems.

Course Objectives:

- Introduce students to the fundamentals of scientific computing and its significance in diverse scientific domains.
- Familiarize students with programming languages and libraries commonly used for scientific computations, such as Python, Julia, or MATLAB.
- Equip students with essential numerical analysis techniques and optimization methods for solving scientific problems efficiently and accurately.
- Develop students' skills in data manipulation, analysis, and visualization to gain insights from scientific datasets.

Learning Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Demonstrate a solid understanding of scientific computing principles, methodologies, and applications.
CO2	Choose an appropriate programming language and effectively implement numerical methods to solve scientific problems.
CO3	Analyse and interpret scientific data using statistical techniques and visualization tools.
CO4	Apply numerical techniques to solve linear and non-linear equations, eigenvalue problems, and differential equations.

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Scientific Computing. Overview of Scientific Computing: Role, significance, and applications in various scientific disciplines. Essential programming concepts: Variables, data types, loops, conditionals, functions, and basic I/O. Introduction to a programming language (Python recommended): Syntax, data structures, and libraries for scientific computing. Numerical methods: Root finding, interpolation, integration, and differentiation. Data visualization: Plotting techniques and tools for presenting scientific data effectively.(20 hours)

Module 2: Data handling and manipulation using libraries such as NumPy, pandas, or equivalent. Statistical analysis of data, including hypothesis testing and regression. Advanced data visualization techniques for scientific presentations. TimInsddee-series analysis and Fourier transforms for signal processing. Data cleaning and preprocessing for scientific datasets. (20 hours)

Module 3: Numerical Linear Algebra. Matrix and vector operations: Addition, subtraction, multiplication, and division. Solving linear systems: Gaussian elimination, LU decomposition, and iterative methods (Jacobi, Gauss-Seidel). Eigenvalue and eigenvector computation. (20 hours)

Module 4: Differential Equations and Optimization. Ordinary Differential Equations (ODEs): First-order and higher-order ODEs, initial value problems, and boundary value problems. Numerical integration methods: Euler's method, Runge-Kutta methods (finite difference, finite element, etc.), and applications. (20 hours)

Module X: Machine Learning for Scientific Computing. Application of machine learning techniques to scientific data analysis and modeling. Advanced topics include neural networks, deep learning, and their applications in scientific computing. Integration of machine learning models with numerical methods for solving complex scientific problems. Evaluation and validation of machine learning models for scientific research and analysis. (10 hours)

Core Compulsory Readings

1. Sastry S.S, INTRODUCTORY METHODS OF NUMERICAL ANALYSIS, 5TH EDN,Prentice Hall India Learning Private Limited, 2012, ISBN: 978-8120345928
2. Germund Dahlquist, Ake Bjorck, Numerical Methods in Scientific Computing, SIAM, 2008, ISBN:9780898716443

Core Suggested Readings

1. Bertil Gustafsson, Fundamentals of Scientific Computing,Springer Science & Business Media, 2011, ISBN: 9783642194948

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

2. Why is scientific computing significant in various scientific disciplines, and what are its key applications?
3. Describe essential programming concepts and their relevance to scientific computing.
4. How do libraries like NumPy and pandas facilitate data handling and manipulation in scientific computing?
5. Discuss the importance of statistical analysis, hypothesis testing, and regression in scientific data analysis.
6. Explain the basic matrix and vector operations used in numerical linear algebra.
7. Compare and contrast Gaussian elimination and LU decomposition methods for solving linear systems.
8. What are the key types of ordinary differential equations, and how are they solved numerically?
9. Describe the various numerical integration methods used for solving differential equations in scientific computing.
10. How can machine learning techniques be applied to scientific data analysis and modelling?
11. Discuss the integration of machine learning models with numerical methods for solving complex scientific problems.

Semester IV

KU4DSCCSE205 DATABASE MANAGEMENT SYSTEM

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	DSC	200	KU4DSCCSE205	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course provides a comprehensive study of database management systems (DBMS), covering both theoretical concepts and practical implementations. Students will gain an understanding of the fundamental principles underlying the design, implementation, and management of modern database systems.

Course Objectives:

- Understand the fundamental concepts of database systems
- Learn about the relational data model, including relations, keys, and referential integrity
- Develop a solid understanding of relational algebra operators and their application in querying databases
- Learn SQL (Structured Query Language)

- Learn about the normalization process and the desirable properties of decompositions up to BCNF
- Understand transaction management, concurrency control, and error recovery mechanisms in database systems

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamental concepts of database systems
CO2	Develop proficiency in developing queries and subqueries
CO3	Gain a deep understanding of the definitions and properties of 1NF, 2NF, 3NF, and BCNF
CO4	Equips students with the knowledge and skills necessary to design, implement, and manage transaction processing systems effectively

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Mechanics: Introduction to database systems, Data Abstraction and System structure, View of Data, Data Models, database structure, DBA, Data Base Users. E-R model, Basic concepts; design issues; Conceptual data modelling - entities, entity types, various types of attributes, relationships, relationship types, E/R diagram notation. Mapping Constraints; Relational Data Model - Concept of relations, keys: Primary, Foreign, candidate, referential integrity and foreign keys (15 hours)

Module 2: Relational algebra operators, various types of joins, set operation, division, example queries, tuple relational calculus, domain relational calculus. SQL - Introduction, data definition in SQL, table. Querying in SQL - basic select-from-where block and its semantics, nested queries - correlated and uncorrelated, notion of aggregation, aggregation functions group by and having clauses. DDL, DML, DCL, SQL Functions, Data types in SQL. Developing queries and subqueries (20 hours)

Module 3: Dependencies and Normal forms - Problems encountered with bad schema designs, motivation for normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FDs, minimal covers, definitions of 1NF, 2NF, 3NF and BCNF, decompositions and desirable properties of them, multi-valued dependencies and 4NF, join dependencies and definition of 5NF (25 hours)

Module 4: Integrity constraints, views, Trigger and Sequences, Relational model – Structure of Transaction processing and Error recovery - ACID properties. Transactions and Schedules – Characterizing Schedules based on Recoverability, Serializability of schedules. Concurrency Control in databases: Locking Techniques-Timestamp ordering, Multi version concurrency Control – Granularity of data items, error recovery and logging, undo, redo, undo-redo logging and recovery methods. (25 hours)

Module X: Overview and History of NoSQL Databases. Definition of the Four Types of NoSQL Databases, NoSQL Key/Value databases, Document Databases, Document oriented Database Features, Graph data model, Column family data model (5 hours)

Core Compulsory Readings

1. 1. H Silbersehatz, Korth and Sudarshan, Database system concepts, 6th edition MGH 2011
2. Ramakrishnan and Gehrke, Database Management Systems, 3rd Edn, Mc Graw Hill, 2003
3. Elmasri and Navathe, Fundamentals of Database systems, 5th Edition, Pearson 2009
4. C.J.Date-A.Kannan, S.Swamynathan, An introduction to Database System, 8th Edition, Pearson education O'Reilly, Practical PostgreSQL Shroff Publishers (SPD) 2002.

Core Suggested Readings

1. Redmond, E. & Wilson, J. (2012). Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement (1st Ed.). Raleigh, NC: The Pragmatic Programmers, LLC. ISBN-13: 978-1934356920 ISBN-10: 1934356921

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to Test Outcomes

1. Describe the role of a Database Administrator (DBA) and different types of database users.
2. Discuss the basic concepts of the Entity-Relationship (E-R) model and explain the components of an E/R diagram.
3. Explain the concept of joins in SQL. Differentiate between inner join and outer join.
4. Provide an example of a relation that violates the third normal form (3NF) and normalize it.
5. What are integrity constraints in database management? Provide examples of different types of constraints.

KU4DSCCSE206 SYSTEM SOFTWARE AND OPERATING SYSTEM

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	DSC	200	KU4DSCCSE206	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course is to provide students with basic knowledge of various system software. Particular emphasis will be given to major OS subsystems: process management (processes, threads, CPU scheduling, synchronization, and deadlock), memory management concepts (segmentation, paging, swapping), file systems, I/O systems and mass storage structure. Introducing open software and Linux basic commands.

Course Objectives:

- To know the design and implementation of system software.
- To explain the main components of OS and their working
- To familiarize the operations performed by OS and various scheduling policies
- To teach the different memory management techniques
- To explain file system, mass storage structure and input/output management.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Identify and Learn different system software
CO2	Describe the types, structure, functions and major concepts of Operating Systems
CO3	Understand the concepts of process, process synchronization, CPU scheduling, deadlocks and file system concepts
CO4	Explain LINUX file system concepts and simple commands

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: System programming – Assemblers, linkers, loaders and compiler (basic ideas). Introduction to compilers: Assemblers: Elements of Assembly Language Programming, Overview of Assembly Process, Design of Two pass Assembler, Macros and Macro Processors, Macro definition, call and expansion, Nested Macro calls, Advanced Macro facilities, Linkers: Linking and Relocation concepts, Design of linkers, Self relocating programs, Linking for overlays. Loaders: introduction to loaders - functions of loaders- Compilers: Introduction to compiler (10 hours)

Module 2: Introduction: Types of OS - Batch Processing System – Multi programming system - Time Sharing System – Real Time System. Operating System Concepts, System Calls – Operating-System Operations -Process management, Memory management, Storage management, Operating system structures - System components, Operating systems services, System calls, Types of system calls (15 hours)

Module 3: Processes: Process concept, Process scheduling, Operations on processes, Inter-process communication. Overview of threads. Process Synchronization: Critical-Section Problem, Semaphores. CPU Scheduling: Basic concepts, Scheduling criteria, Scheduling algorithms - First come First Served, Shortest Job First, Priority scheduling, Round robin scheduling (20 hours)

Module 4: Deadlocks: System Model, Necessary conditions, Methods for Handling Deadlocks, Deadlock prevention, Deadlock avoidance - Banker's algorithms, Deadlock detection, Recovery from deadlock. Memory Management: Concept of address spaces, Swapping, Contiguous memory allocation, Segmentation, Paging. Virtual memory, Demand paging, Page replacement algorithms (25 hours)

Module X: File System: File concept, Access methods, Tree-structured directories, File system mounting, Protection. File System Implementation: File System structure, implementation. Unix : History of Unix OS, Open Source Software - Issues, Portability, Documentation, Best Practices for Working with Open Source Developers, Varieties of Open Source Licenses, Free Software vs Open Source software. Understanding File system, File Ownership and Permission. Shell - Types, Responsibilities. Basic Commands - cd, mkdir, echo, ls, pwd, rm, who, date, cp, mv, cat, ps. Working with Directories, Standard Input/Output, and I/O Redirection, pipes (5 hours)

Core Compulsory Readings

1. D.M. Dhamdhere, Systems Programming and Operating Systems, TMH, 2003.
2. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne (2013). Operating System Concepts, 9th edition, John Wiley & Sons.
3. Wood, P., Kochan, S. G. (2016), Shell Programming in Unix, Linux and OS X, 4th edition, Pearson Education.

Core Suggested Readings

1. Andrew S. Tanenbaum, Herbert Bos (2016). Modern Operating Systems, 4th edition, Pearson Education India
2. William Stallings (2018), Operating systems - Internals and Design Principles, 9th Edition, Pearson Education, PHI.
3. Raymond, E. S. (2009). The Art of UNIX Programming, 3rd Edition, Pearson Education.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Sample Questions to Test Outcomes

1. Mention any two deadlock prevention mechanisms.
2. What is fork()?
3. List out different types of files
4. Define OS.
5. What is a process?
6. Explain the shortest job first scheduling algorithm.
7. What are the necessary conditions for deadlock?
8. Explain about bounded buffer problem
9. With example explain system calls
10. Explain about round robin scheduling.

KU4DSCCSE207 DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	DSC	200	KU4DSCCSE207	4	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	0	1	50	50	100	2

Course Description: Digital Electronics and Computer Organization is an introductory course that delves into the fundamental principles underlying modern digital systems and computer architecture. The course is designed to provide students with a comprehensive understanding of digital circuits, logic design, CPU architecture, and the organization of computer systems. Students will explore the concepts of binary arithmetic, Boolean algebra, Combinational and sequential logic, instruction execution, and CPU operation.

Course Objectives:

- Understand different number systems and Boolean algebra.
- Design of Combinational and sequential logic circuits
- Understand different Computer Instructions
- Understand concepts of register transfer logic and arithmetic operations.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Able to perform the conversion among different number systems.
CO2	Able to design Combinational and sequential logic circuits
CO3	To present the Digital fundamentals, Boolean algebra and its applications in digital systems
CO4	To familiarize with the design of various digital circuits using logic gates

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Number Systems – Decimal, Binary, Octal, Hexadecimal number, Number Conversion, binary arithmetic, 1's and 2's complement arithmetic, BCD arithmetic, Boolean Laws: Commutative Laws, Associative Laws and Distributive Laws, Boolean Theorems, Sum of Products and Product of Sums. (10 hours)

Module 2: De-Morgan's Laws, Digital Logic Gates:-AND, OR, NOT,XOR,XNOR functions, Universal Logic Gates: NAND and NOR gates, Realization of Boolean expressions using logic gates, Circuit simplification using Boolean Algebra, Logic Diagrams, Combinational Logic Circuits, Simplification of Logic functions, Karnaugh map simplification (20 Hours)

Module 3: Multiplexer, and De-multiplexer: Truth table and logic expression, Implementation using logic gates, Design of Half adder and full adder, Construction of full adder using half-adders, Decoder, Encoder, Digital to analog converter, Analog to digital converter. (25 hours)

Module 4: Concept of Flip-flops, SR latch, Gated SR latch, Shift Registers, Serial in – Serial out Shift Register (SISO), Serial In – Parallel out shift Register (SIPO), Parallel in – Parallel out Shift Register (PIPO), Parallel in – Serial out Shift Register (PISO), Bidirectional Shift Registers, Accessing I/O Devices, Interrupts – Interrupt Hardware, Direct Memory Access, Buses, Basic concepts of Pipe lining. (25 hours)

Module X: Instruction formats, Instruction sets, Instruction Formats, Addressing Modes, Data Transfer and Manipulation, memory organization: Memory Hierarchy, Main memory, Auxiliary memory, Associate memory, Cache memory, Complex Instruction Set Computer (CISC) Reduced Instruction Set Computer (RISC),Register Transfer Language, Register Transfer, Bus and Memory Transfers. (10 hours)

Core Compulsory Readings

1. M. Morris Mano, Michael D. Ciletti, "Digital Design", Pearson, 2013.
2. A. K. Maini, "Digital Electronics: Principles, Devices And Applications, Wiley, 2007.
3. R. Gaonkar, "Microprocessor Architecture, Programming and Applications with the 8085", Prentice Hall, 2014.
4. "Digital Design and Computer Architecture" by David Harris and Sarah Harris.

TEACHING LEARNING STRATEGIES

- Lecturing, case study/mini projects, Team Learning, presenting seminars on selected topics, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 4 Credit Theory.

Sample Questions to Test Outcomes

1. How does a NAND gate differ from a NOR gate?
2. How does a NOT gate function?
3. Explain the operation of an AND gate.
4. Can you simplify the Boolean expression (A + B)(A + ¬B) using Boolean algebra?
5. What is meant by the term "instruction execution cycle"?
6. Compare the performance and functionality of half adders and full adders
7. In what scenarios would you prefer using a full adder over a half adder
8. Define the term "combinational circuit."
9. What is the purpose of a multiplexer?
10. Explain the operation of a shift register.

KU4DSCCSE208 DATA & BUSINESS ANALYTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	DSC	200	KU4DSCCSE208	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course provides an understanding of principles involved in Data and Business Analytics at conceptual level. It describes application areas for studying and implementing Business intelligence. It depicts necessary developing skills to design business analytics and Intelligence projects using data mining and data warehousing concepts.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Demonstrate the awareness and Knowledge of Business Analytics
CO2	Apply the basic concepts of analytics to the business scenarios and extend the knowledge about future trends in business analytics.
CO3	Assess the relevance and effectiveness of business analytics solutions
CO4	Apply the knowledge of technical skills in descriptive and predictive modelling to support business decision-making

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Business Analytics: Concept of analytics, Types of Analytics, Application fields - Marketing Analytics, Finance Analytics, HR Analytics, Operation Analytics, organization and source of data, importance of data quality, dealing with missing or incomplete data, Role of Data Scientist in Business & Society (10 hours)

Module 2: Data Modeling: Identify the role of data modeling in the organization - Analyze data modeling techniques - Use tools for data modeling - Structured Data Tools: Identify core tools for RDBMS's (structured storage) - Use SQL to perform CRUD tasks against a database - Unstructured Data Tools: Identify tools in unstructured stack - Use tools for unstructured data management (15 hours)

Module 3:

Analytics Methodology: Introduction to Analytics Methodology, preparing objectives & identifying data requirements, Data Collection, Understanding data, Data preparation – Data Cleansing, Normalisation, Data preparation, Data Blending, Data Modelling, Evaluation & feedback (20 hours)

Module 4: Visualisation of Data: Introduction, Data summarization methods; Tables, Graphs, Charts, Histograms, Frequency distributions, Relative Frequency Measures of Central Tendency and Dispersion; Box Plot; Basic probability concepts, conditional probability, Probability distributions, Continuous and discrete distributions, sequential decision making. (25 hours)

Module X :

Business Analytics Future Trends: Role of Artificial Intelligence in Business, Machine Intelligence, Competitive Intelligence, Text Mining, Web Analytics (Web content mining, Web usage mining, Web structure mining), Role of Intelligent Agents in e-business, e-commerce, m-commerce, Location Analytics, Intelligent Agent in search & retrieval, Personalization and Comparison), Social Networking Analysis, Ethical and Legal considerations in Business Analytics (5 hours)

Core Compulsory Readings

1. Turban E, Armson, JE, Liang, TP &Sharda, Decision support and Business Intelligence Systems, 8th Edition, John Wiley & Sons, 2007
2. Frank J. Ohlhorst, Big Data Analytics, 1st Edition, Wiley, 2012.
3. Efraim Turban, Ramesh Sharda, Jay Aronson, David King, Decision Support and Business Intelligence Systems, 9th Edition, Pearson Education, 2009

Suggested Readings

1. D R N Prasad, Seema Acharya: Fundamentals of Business Analytics, Wiley India, Second Edition, 2016.
2. David Loshin: Business Intelligence: The Savvy Manager's Guide., Latest Edition By Knowledge Enterprise. 2012
3. J.Han and M. Kamber: Data Mining: Concepts and Techniques By Morgan Kaufman publishers, Harcourt India pvt. Ltd. Latest Edition
4. Larissa Terpeluk Moss, ShakuAtre: Business Intelligence roadmap by Addison Weseley
5. CindiHowson: Successful Business Intelligence: Secrets to making Killer BI Applications by Tata McGraw Hill

6. Mike Biere: Business intelligence for the enterprise by Addison Weseley, August 2010.
7. Efraim Turban, Ramesh Sharda, Jay Aronson, David King, Decision Support and Business Intelligence Systems, 9th Edition, Pearson Education, 2009.
8. S. Christian Albright, Wayne L. Winston, Business Analytics: Data Analysis & Decision Making, 6th Edition, CENGAGE INDIA , 2017

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

KU4DSCCSE301 FOUNDATION OF ELECTRICAL AND ELECTRONICS ENGINEERING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	ELECTIVE	300	KU4DSCCSE301	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description: The course "Foundation of Electrical and Electronics Engineering" covers fundamental topics including electrical circuits, electronics, operational amplifiers, and electrical machines. Students learn circuit analysis techniques, semiconductor devices, operational amplifier circuits, and principles of electrical machines such as DC motors and transformers. Through theoretical learning and practical exercises, students acquire foundational knowledge essential for pursuing advanced studies and applications in electrical and electronics engineering.

Course Objectives:

- Provide a comprehensive understanding of electrical circuit fundamentals, including analysis techniques and network theorems.
- Introduce semiconductor devices like diodes and transistors and their applications in electronic circuits.
- Teach practical circuit design using operational amplifiers, covering topics such as voltage summing and active filters.
- Explore the principles and applications of electrical machines, focusing on DC motors and single-phase transformers.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Proficiency in analyzing and solving complex electrical circuits using various techniques and network theorems.
CO2	Competence in designing and implementing electronic circuits utilizing semiconductor devices like diodes and transistors.
CO3	Ability to design practical circuits employing operational amplifiers for applications such as voltage summing and active filtering.
CO4	Understanding of electrical machine principles and their applications, enabling the design and analysis of DC motors and single-phase transformers.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Electrical Circuits: Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source. Transformations, Thevnin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance. (20 hours)

Module 2: Electronics- Diodes and Transistors: Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, Bipolar Junction Transistors, Transistor Biasing, , Transistor Amplifier, Transistor Oscillators (20 hours)

Module 3: Operational Amplifiers: Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Circuits, Active Filters and Oscillators. (20 hours)

Module 4: Electrical Machines: Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, Voltage equation of a motor, significance of back emf, Speed, Torque, Torque-Speed characteristics, Output Power, Efficiency and applications. Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer (20 hours)

Module X : Magnetic circuits

Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Electromechanical Energy Conversion, Introduction to Rotating Machines. (10 hours)

Core Compulsory Readings

1. C. K. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.

Core Suggested Readings

1. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.

2. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
3. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
4. Floyd and Jain, Digital Fundamentals, 8th Edition, Pearson.
5. A. E. Fitzgerald, C. Kingsley Jr. and S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
6. D. P. Kothari and I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.
7. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1. Explain the process of nodal analysis and its significance in circuit analysis.
2. How do you determine the time-domain response of an RL circuit to a sinusoidal forcing function?
3. Describe the operation of a Zener diode and its applications in electronic circuits.
4. What are the functions of clipper and clamper circuits, and how are they implemented using diodes?

5. Discuss the concept of DC offset in operational amplifiers and its effects on circuit performance.
6. How can an operational amplifier be configured as a voltage summing circuit?
7. Explain the principle of operation of a DC motor and discuss its torque-speed characteristics.
8. What factors affect the regulation and efficiency of a single-phase transformer?

Semester V

KU5DSCCSE302 JAVA TECHNOLOGIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSC	300	KU5DSCCSE302	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE duration : 2 hours for theory and 3 hours for Lab**

Course Description:

By the end of this course, students will have a solid foundation in Java programming and web development concepts, equipping them with the skills needed to develop robust Java applications and web solutions.

Course Objectives:

- Fundamental Understanding of Java
- Master multithreading concepts and techniques.
- Understand AWT's abstract window toolkit.
- Understand JDBC architecture, JDBC drivers, and steps to connect to a database.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understanding Java Basics and students will gain proficiency in object-oriented programming concepts
CO2	Proficiency in multithreading concepts, expertise in performing input and output operations and developing skills in GUI programming using Java AWT and Swing.
CO3	Understand the architecture of JDBC and various JDBC drivers, and learn how to manage database transactions and handle errors effectively using JDBC
CO4	Develop skills in creating, deploying, and managing Java servlets, gain proficiency in JavaServer Pages (JSP).

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1

Features of Java, Byte code, JDK, JRE, JVM, Data Types -Type Conversion and Casting, Variables, Operators, Control Statements, Looping Statements, Arrays, Strings, Class, Objects-Declaring Objects, Access Specifier, Static, Nested and Inner Classes, this Keyword, Garbage Collection, Methods- method overloading, Constructors, Inheritance-Method Overriding, Dynamic Method Dispatch, Abstract Classes, Interface- Defining an Interface, Implementing Interfaces, Packages - Declaring a package, Importing Packages, Sub-packages, Exception Handling - Types of Exceptions, try-catch, throw, throws, and finally (20 hours)

Module 2

Thread - Life cycle of a thread, Synchronization, Thread class & Runnable interface, Multithreading. I/O streams, File streams: File Input Stream and File Output Stream, Data Input and Output Streams, Buffered Input and Output Streams Applets- Applet life cycle, working with Applets, Working with Graphics: Abstract Window Toolkit (AWT) - Components: Container, Panel, Window, Frame. AWT Controls, Listeners, Layout Managers, Event Handling - Events, Event Sources, Event Classes, Event Listener Interfaces, Adapter Classes. Swing (JFC) - Swing components (20 hours)

Module 3

Database connectivity - JDBC architecture, JDBC Drivers, Steps to connect to Database- Connectivity with MySQL, Driver Manager, Types of JDBC statements: Statement, Prepared statement, Callable statement, ResultSet - Types of ResultSet, blobs and clobs,metadata - Database Metadata, Resultset Metadata, transactions, error handling (20 hours)

Module 4

Model-View-Controller (MVC) Architecture, Java Servlets: Introduction to servlet, Servlet life cycle, Developing and Deploying Servlets, Generic and http servlets, GET, POST, HEAD and other requests, Servlet responses, error handling, security, servlet chaining, cookies, session tracking , Java Server Pages: Introduction to JSP, JSP life cycle, JSP expressions and declarations, Directives and Actions: Page directives, JSP actions and implicit objects, JSP Tag Libraries: Standard and Custom Tag Libraries, Expression Language (EL) (20 hours)

Module X :

Spring Framework: Introduction to Spring: Dependency Injection (DI) and Inversion of Control (IoC),Spring AOP (Aspect-Oriented Programming),Spring MVC :Configuring Spring MVC, Handling web requests, Hibernate: Introduction to Hibernate :Object-Relational Mapping (ORM) Hibernate architecture , Mapping in Hibernate :Mapping Java classes to database tables, HQL (Hibernate Query Language)

Core Compulsory Readings

1. Herbert Schildt, The complete reference Java2 ,11thed, Released December 2018
1. Publisher(s): McGraw-Hill ISBN: 9781260440249
2. JasonHunder& William Crawford, Java Servlet Programming, O'REILLY, 2002
3. Marty Hall, Larry Brown Core Servlets and Java server pages. Vol 1: Core Technologies. 2nd Edition.

Core Suggested Readings

1. David Flanagan, Java in a Nutshell A desktop quick Reference, 7 Edition, 2018. OReilly& Associates Inc
2. Rajkumar, Java programming, Pearson, 2013
3. Harimohan Pandey, Java Programming, Pearson, 2012
4. David Flanagan, Jim Parley, William Crawford & Kris Magnusson , Java Enterprise in a nutshell- A desktop Quick reference -O'REILLY, 2005
5. Stephen Ausbury and Scott R. Weiner, Developing Java Enterprise Applications, Wiley-2001
6. Database Programming with JDBC and Java, Reese George, Oreilly
7. Christian Bauer, Gavin King, and Gary Gregory, "Java Persistence with Hibernate" 2015
8. Craig Walls "Spring in Action" 2022
9. Christian Bauer and Gavin King, "Hibernate in Action" 2004

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

1. Explain the difference between JDK, JRE, and JVM. How do they contribute to the execution of Java programs?
2. Discuss the role of try-catch blocks in Java exception handling. Provide an example scenario where you would use each of the following: throw, throws, and finally.
3. What is synchronization in Java multithreading? Why is it necessary? Explain the life cycle of a thread in Java.
4. Describe the steps involved in establishing database connectivity using JDBC with MySQL

KU5DSCCSE303 COMPUTER NETWORK

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSC	300	KU5DSCCSE303	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description:

This course exposes the fundamental concepts of main concepts of networking to the learner. TCP/IP network model is taken as the basis for the discussion. The course provides the learner a brisk walk through the fundamental concepts of application layer, transport layer, data link layer, and transport layer.

Course Objectives:

- Provide basic knowledge of the concepts of computer networks
- Give a basic idea about the OSI Model and TCP/IP Network models
- Familiarize with the basic concepts of various layers in TCP/IP network model

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the features of computer networks, protocols, and network design models
CO2	Illustrate the functions and various algorithms / protocols used of application layer and transport layer of TCP/IP model
CO3	Explain the functions and various algorithms / protocols used of network layer of TCP/IP model
CO4	Describe the functions and various algorithms / protocols used of data link layer of TCP/IP model

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Internet: Description - Protocol - Network Edge - Network Core. Performance Metrics: Delay - Loss - Throughput. Layered Architecture - The Internet protocol stack - OSI reference model. Application Layer: Network

Application Architectures - Communication of Processes - Services for Transport - Application Layer Protocols. Web and HTTP: HTTP - Persistent and Non Persistent - HTTP Message Format. Socket Programming with UDP and TCP. (20 hours)

Module 2: Transport Layer: Services - Relationship between Transport and Data Link Layer - Multiplexing and Demultiplexing. UDP - Segment Structure - Checksum - Principles of Reliable Data Transfer - GBN - SR. TCP: Connection - Segment Structure - Segment and Acknowledgement Numbers - Reliable Data Transfer Flow Control - Congestion Control. (20 hours).

Module 3: Network Layer: Forwarded Routing - Service Models - VC and Datagram Networks - Functioning of a Router. IP - IPV4 Addressing - Interface Address - Subnet - Netmask - CIDR - ICMP - IPV6 Addressing - Datagram Format - IP V4 to V6 Transition. Routing Algorithms: LS - DV. Intra AS Routing in Internet: RIP - OSPF. (20 hours)

Module 4: Data Link Layer: Services - NIC. Error detection and Correction: CheckSum - Parity - CRC. Multiple Access Links and Protocols: Channel Partitioning Protocol - Random Access Protocols: ALOHA - CSMA - CSMA/CD. Link Layer Addressing: MAC Address - ARP. Ethernet: Frame Structure - Technologies. Link Layer Switches Vs Routers. (20 hours)

Module X (Teacher Specific): Cookies - SMTP - RTT Estimation - Inter AS Routing on the Internet: BGP - IEEE 802.3 - Case Study: A Day in the Life of a Web Page Request - Data Centre Networking. (10 hours)

Core Compulsory Readings

1. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6th Edition.

Core Suggested Readings

1. Gerry Howser, Computer Networks and the Internet: A Hands-On Approach, Springer, ISBN-13: 9783030344955, 2019.
2. A. Tanenbaum and D. Wetherall, Computer Networks, 5th edition, Pearson, ISBN-13: 9780132126953, 2013.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes.

1. Define simplex, half-duplex, and full-duplex transmission modes.
2. "Data link protocols almost always put the CRC in a trailer rather than in a header". Justify.
3. Compute the number of octets the smallest possible IPv6 (IP version 6) datagram ?
4. Distinguish the features of UDP and TCP
5. Illustrate the concept of netmask with a suitable example
6. Explain any one random access protocol.

KU5DSCCSE304 SOFTWARE ENGINEERING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSC	300	KU5DSCCSE304	4	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	0	1	50	50	100	2

Course Description:

This course provides an overview of Software Engineering. It provides the fundamental aspects of the topic and covers the various process models available for creating software projects. It provides insight into the requirement engineering and discusses various techniques for modeling requirements. Fundamentals of software design and component level design in particular is also covered. The course also provides insight into the principles of user interface design, project estimation, scheduling, and testing strategies.

Course Objectives:

- Introduce the basic concepts of software engineering.
- Give basic idea of various software process models.

- Familiarize various processes of software development.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand what software engineering is and its importance, characteristics of software, and challenges in the field.
CO2	Explore various software development life cycle models and the principles of agile methodologies.
CO3	Learn techniques for requirements gathering, analysis, and modeling; understand the fundamentals of software design and architecture.
CO4	Discuss strategies for ensuring software quality, introduction to software testing methodologies, and understanding the importance of software security

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Software Engineering, Nature of Software, Software Application Domains, Legacy Software (20 hours)

Module 2: Process Models, Agility and Agile Processes, Scrum, XP, Kanban, DevOps (20 hours)

Module 3: Understanding Requirements, Requirements Modeling, Design Concepts, Architectural Design, Component-Level Design, User Experience Design (20 hours)

Module 4: Quality Concepts, Software Reviews, Software Quality Assurance, Software Security Engineering, Software Testing at Component and Integration Levels (20 hours)

Module X (Teacher Specific): Quality Concepts, Software Reviews, Software Quality Assurance, Software Security Engineering, Software Testing at Component and Integration Levels (10 hours)

Core Compulsory Readings

1. Pressman RS Maxim BR. Software Engineering: A Practitioner's Approach. 9th ed. McGraw-Hill Higher Education; 2019.

Core Suggested Readings

1. Hans van Vliet, Software Engineering: Principles and Practice.
2. Robert C. Martin and Martin Fowler,Agile Software Development: Principles, Patterns, and Practices.

TEACHING LEARNING STRATEGIES

- Lecturing, Case study, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses (4 Credit theory).

Sample Questions to test Outcomes.

1. How do you handle software requirements changes during a project?
2. Can you describe the Agile software development methodology and its advantages?
3. What is the difference between unit testing and integration testing?
4. Explain concept of data flow diagram.
5. Give a description of the prototyping model.

KU5DSCCSE305 MACHINE LEARNING TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSC	300	KU5DSCCSE305	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

2	4	1	50	50	100	2(T)+3(P)*

*** ESE duration : 2 hours for theory and 3 hours for Lab**

Course Description:

This course is intended to familiarize the learners about the fundamental concepts in machine learning and deep learning mechanism for applying and analysing the huge volume of data generated in real life. The main purpose of this course is to provide a foundational understanding of machine learning models and demonstrate how it will be useful for solving complex problems in the real world.

Course Objectives:

- Aims to impart basic concepts of Artificial intelligence
- Impart knowledge on different learning scenario in machine learning
- Acquire the knowledge of various machine learning models and its implementation
- Understand various neural networks models architecture and its training algorithms
- Awareness of various dimensionality reduction techniques for optimizing the feature extraction techniques for improving the performance of various classification models.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	To introduce the prominent methods for machine learning
CO2	To study the basics of supervised and unsupervised learning

CO3	To study the basics of neural networks
CO4	To study the basics of deep learning architectures

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Machine Learning: Concept of the learning task, inductive learning, and the concepts of hypothesis space, introduction to different types of machine learning approaches, examples of machine learning applications, different types of learning: supervised learning, unsupervised learning, reinforcement learning. Feature Extraction- Setting up your machine learning platform: training, validation and testing, overfitting and under-fitting, different types of error calculation. (15 hours)

Module 2: Regression- Linear regression and logistic regression- Supervised Learning: Introduction, learning a class from example, learning multiple classes, Unsupervised Learning: Introduction, clustering; mixture densities, k-means clustering and hierarchical clustering. (20 hours)

Module 3: Dimensionality reduction: principal component analysis, linear discriminant analysis, canonical correlation analysis. Introduction to Artificial Neural Network: Understanding brain, perceptron, Multi-Layer perceptron as universal approximator, general architecture of artificial neural network, feed forward and back propagation, different linear and nonlinear activation functions for binary and multi class classification. (25 hours)

Module 4: Introduction to Deep Learning: Fundamentals of deep learning, Deep Feedforward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Introduction to Convolutional Networks, Sequence Modelling using Recurrent Nets, overview of LSTM, fundamentals of Generative adversarial Networks. (25 hours)

Module X: Feature Extraction - Testing the quality of features Reinforcement Learning, Transfer Learning Anomaly Detection and Outlier Analysis, Natural Language Processing (NLP), Graph Neural Networks (GNNs), Adversarial Machine Learning

Core Compulsory Readings

1. Ethem Alpaydin, Introduction to Machine Learning- 3rd Edition, PHI.
2. Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning (Adaptive Computation and Machine Learning), MIT Press, 2016.

Core Suggested Readings

1. Tom M. Mitchell, Machine Learning, McGraw-Hill
2. Kuntal Ganguly, Learning Generative Adversarial Networks, Packt Publishing, 2017.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

1. What are the key differences between supervised, unsupervised, and reinforcement learning? Provide examples of real-world applications for each type of learning.
2. Explain the concepts of over-fitting and under-fitting in machine learning models. How can these issues be addressed during the training and validation process?
3. Compare and contrast linear regression and decision tree learning approaches in supervised learning. When would you choose one over the other for a given problem?
4. How does model selection impact the generalization performance of a supervised learning algorithm? Discuss techniques for selecting the best model among multiple candidates.
5. Describe the process of clustering using the k-means algorithm. What are the advantages and limitations of k-means clustering compared to hierarchical clustering?
6. Explain how Latent Dirichlet Allocation (LDA) is used for topic modeling in unsupervised learning. What are some real-world applications of LDA?
7. What are the primary objectives of dimensionality reduction techniques such as principal component analysis (PCA) and linear discriminant analysis (LDA)? How do these techniques differ in their approach?
8. Discuss the architecture and training process of a Multi-Layer Perceptron (MLP) neural network. How do feedforward and backpropagation algorithms contribute to learning in MLPs?

S5 - List of Discipline Specific Electives (DSE) (POOL D)

KU5DSECSE306 OPERATING SYSTEM SECURITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	DSE	300	KU5DSECSE306	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

With a focus on Windows and Linux operating systems in particular, this course covers basic operating system ideas, exploring fundamental concepts such as architecture, memory management, file system management, I/O management, network operating systems, and distributed operating systems. It delves into the installation, configuration, and security of both Windows and Linux. Additionally, the course examines cloud computing and virtualization topics including zero-trust security architecture, cloud provisioning, PaaS and SaaS models, private and public cloud environments, and cloud security. The Linux module also encompasses bash scripting.

A comprehensive understanding of operating systems, virtualization, cloud computing, and their corresponding security measures is provided within the course.

Course Objectives:

- Provide a foundational understanding of operating systems, their functions, and their importance in computer systems
- Gain knowledge of the underlying architecture and components of the Windows and Linux operating systems
- Learning Windows and Linux operating system features—system administration and security
- Understand the fundamentals of virtualization and cloud computing

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand how to install and update Windows 11 and Server 2019, Linux and configure GRUB boot loader
CO2	Install, configure, manage, and maintain active directory domain services
CO3	Configure basic Linux network services
CO4	Understand Cloud Computing, Cloud Types and Cloud Service Deployment Models (PaaS, SaaS) and the concept of Cloud Security

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Fundamental operating system concept: Basic Concepts of Operating system – Architecture – Process management- Memory management- File system management- I/O Management – Basics of Network Operating Systems – Basics of Distributed Operating system (10 hours)

Module 2: Windows Operating system: History of Windows OS and Fundamentals - Installation of Windows Operating System Windows 11 and Server 2019 - Updating windows system and patch management-Windows File system and Disk Management- Active Directory and windows domain-Windows Security and OS Hardening-Virtualization using Hyper-V-Network Based installation method-Network Configuring- Implementation of infrastructure of windows networks- Active Directory Domain Services (ADDS)-DNS, DHCP and IPAM, Network Policy Server (NPS), Local Policies, Group Policies, Flexible Single Master Operation (FSMO)-File Server Resource Manager (FSRM), Windows Server Backup (WSB) (15 hours).

Module 3: Linux Operating system: Linux Fundamentals – (Startup Files, Linux boot process), Basic Commands of Linux, Installation of Linux- Configuring the GRUB boot loader, Disk management and partition, Controlling and managing Services, -Linux Authentication method and User administration-Linux File System and permissions -Methods for installation of Packages. Apt-get and YUM/DNF Package manager. Network configurations- configuration of NFS, FTP and DHCP Servers. Linux Security and OS Hardening. Virtualization using KVM (20 hours)

Module 4: Virtualization and cloud computing: Virtualization concepts - Cloud fundamentals – architecture -Private cloud environment-Public cloud environment - Auto-provisioning-Cloud as PaaS, SaaS-Cloud computing securitization (25 hours)

Module X: Power shell Scripting - Windows Administration using power shell, Background Jobs and Remote Administration - Bash Scripting, Introduction to BASH Command Line Interface (CLI) Error Handling Debugging & Redirection of scripts, Automate Task Using Bash Script, Security patches, Logging & Monitoring using script - Ethics and standard of cloud Cloud Data Security - Cloud Application Security - Zero Trust Security Architecture (5 hours)

Core Compulsory Readings

1. Silberschatz, Greg Gagne, and Peter Baer Galvin, Operating System Principles, 7th Edition
2. Richard Peterson, Linux: The complete reference, 6th Edition
3. DacNhuong L, RaghvendraKumar, Virtualization and Cloud Computing, John Wiley and Sons
4. Richard Fox, Linux with operating system concepts
5. Christal Panek, Windows operating system fundamentals

Core Suggested Readings

1. Bruce Payette, Windows PowerShell in Action

2. Harlan Carvey, Windows Registry Forensics: Advanced Digital Forensic Analysis of the Windows Registry
3. Christopher Negus, Linux Bible
4. Evi Nemeth, Garth Snyder, Trent R. Hein, and Ben Whaley, UNIX and Linux System Administration Handbook
5. Jeremy Moskowitz, Group Policy: Fundamentals, Security, and the Managed Desktop
6. Richard Blum and Christine Bresnahan, Linux Command Line and Shell Scripting Bible

TEACHING LEARNING STRATEGIES

- Hands-on-oriented teaching, collaborative learning, case studies and project presentations, peer-led discussions.

MODE OF TRANSACTION

- Lecture, seminar, discussion, audio and video presentation, demonstration, practical assignments, and exercises.

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

KU5DSECSE307 INTRODUCTION TO DIGITAL FORENSIC

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSE	300	KU5DSECSE307	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

With a focus on Windows and Linux operating systems in particular, this course covers basic operating system ideas, exploring fundamental concepts such as architecture, memory management, file system management, I/O management, network operating systems, and distributed operating systems. It delves into the installation, configuration, and security of both Windows and Linux. Additionally, the course examines cloud computing and virtualization topics including zero-trust security architecture, cloud provisioning, PaaS and SaaS models, private and public cloud environments, and cloud security. The Linux module also encompasses bash scripting.

A comprehensive understanding of operating systems, virtualization, cloud computing, and their corresponding security measures is provided within the course.

Course Objectives:

- To understand computer forensics principles, techniques, and methodologies, including data acquisition and recovery.
- To learn to identify, collect, and preserve digital evidence from crime scenes, following legal standards.

- To analyze and validate forensics data to ensure integrity, addressing challenges like data hiding.
- To evaluate digital forensics tools in real-time applications, considering their effectiveness in investigations.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of computer forensics principles, techniques, and methodologies, including data acquisition and recovery processes.
CO2	Acquire the skills necessary to identify, collect, and preserve digital evidence from crime and incident scenes, while adhering to proper procedures and legal standards.
CO3	Analyze and validate forensics data using advanced techniques to ensure its integrity and reliability, while addressing challenges such as data hiding techniques.
CO4	Evaluate the role of digital forensics tools and technologies in real-time applications, exploring their capabilities and limitations in investigative processes and incident response scenarios.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Computer Forensics and Investigation: Understanding computer forensics, Preparing for Computer Investigations, Corporate High-Tech Investigation. Data Acquisition and Recovery. Storage formats, Using acquisition tools, Data Recovery: RAID Data acquisition (10 Hours)

Module 2: Processing Crime and Incident Scene: Identifying and collecting evidence, Preparation for search, Seizing and Storing Digital evidence. Computer Forensics tools (Encase) and Windows Operating System. Understanding file structure and file system, NTFS disks, Disk Encryption and Registry. Manipulation. Computer Forensics software and hardware tools (15 Hours)

Module 3: Computer Forensics Analysis and Validation: Data collection and analysis, validation of forensics data, addressing – data hiding technique. Email Investigation and Mobile device Forensics- Investigation e-mail crimes and

Violations, Using specialized E-mail forensics tools. Understanding mobile device forensics and Acquisition procedures (20 Hours)

Module 4: Role of Digital Forensics in Real time applications - SANS SIFT Investigative tool, PRO Discover Basic, Volatility, Sleuth Kit, CAINE investigative environment. Industry Trends (25)

Module X : Network Forensics, Memory Forensics, File Carving and Data Carving, Malware Forensics, Anti-Forensics Techniques, Cloud Forensics, IoT (Internet of Things) Forensics, Forensic Data Analysis and Visualization, Legal and Ethical Considerations (5 Hours)

Core Compulsory Readings

1. Bill Nelson, Amelia Philips, Christopher Steuart, Guide to Computer Forensics and Investigations, Fourth Edition, Cengage Learning, 2016.

Core Suggested Readings

1. David Lilburn Watson, Andrew Jones, Digital Forensics Processing and Procedures, Syngress, 2013.
2. Cory Altheide, Harlan Carvey, Digital Forensics with Open-Source Tools, British Library Cataloguing-in-Publication Data, 2011
3. Greg Gogolin, Digital Forensics Explained, CRC Press, 2013.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

KU5DSECSE308 MOBILE COMPUTING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSE	300	KU5DSECSE308	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

The purpose of this course is to understand the concept of mobile computing paradigm, novel applications, limitations and also to impart knowledge on the typical mobile networking Infrastructure through a popular GSM protocol. It also helps the students to get exposed to Ad-Hoc Networks and gain knowledge about different mobile platforms and application development.

Course Objectives:

- To infer knowledge about mobile communications and its services.
- To Identify several communication access techniques.
- To illustrate technical format, addressing and transmission strategies of packets.
- To determine the functionality of MAC, Network layer and identifying a routing protocol for given Ad Hoc Networks and Perceive knowledge about TCP and failure recovery method.
- To identify and solve database issues using hoarding techniques.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Infer knowledge about mobile communications and its services.
CO2	Identifying several communication access techniques.
CO3	Illustrate technical format, addressing and transmission strategies of packets.
CO4	Determine the functionality of MAC, Network layer and identifying a routing. protocol for given Adhoc Networks and Perceive knowledge about TCP and failure recovery methods.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Mobile Computing - Architecture of Mobile Computing - Novel Applications – Limitations. GSM - GSM System Architecture - Radio Interface – Protocols - Localization and Calling - Handover - Security - New Data Services. (20 hours)

Module 2: Medium Access Control Protocol - Wireless MAC Issues - Hidden and exposed terminals - near and far terminals – SDMA – FDMA – TDMA – CDMA - Tunnelling Cellular Mobility - IPv6. (20 hours)

Module 3: Mobile IP – Goals – Assumption - Entities and Terminology - IP Packet Delivery - Agent Advertisement and Discovery – Registration - Tunnelling and Encapsulation – Optimizations -Dynamic Host Configuration Protocol. (20 hours)

Module 4: Traditional TCP - Indirect TCP - Snooping TCP - Mobile TCP - Fast Retransmit and Fast Recovery - Transmission /Time-Out Freezing - Selective Retransmission - Transaction Oriented TCP.(20 hours)

Module X: Hoarding Techniques - Caching Invalidation Mechanisms - Client Server Computing with Adaptation- Power Aware and Context Aware Computing - Transactional Models - Query Processing – Recovery - and Quality of Service Issues.

Core Compulsory Readings

1. Jochen Schiller, "Mobile Communications", Second edition Addison-Wesley, 2008.
2. Reza Behravanfar, "Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML", Cambridge University Press, October 2004.

Core Suggested Readings

1. Adelstein, Frank, Gupta, Sandeep KS, Richard III, Golden, Schwiebert, Loren, "Fundamentals of Mobile and Pervasive Computing", McGraw-Hill Professional, 2005.

2. Hansmann, Merk, Nickolas, Stober, "Principles of Mobile Computing", second edition, Springer, 2003.Martyn Mallick, "Mobile and Wireless Design Essentials", Wiley DreamTech, 2003.

3. Ivan Stojmenovic and Cacute, "Handbook of Wireless Networks and Mobile Computing", Wiley, 2002.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. Explain the architecture of mobile computing and discuss its novel applications. What are the limitations of mobile computing?

2. Describe the GSM system architecture, including the radio interface, protocols, localization, calling, handover, and security mechanisms.

3. Discuss the challenges and issues related to wireless MAC protocols, including hidden and exposed terminals, near and far terminals, and techniques such as SDMA, FDMA, TDMA, and CDMA.

4. Explain the concept of tunneling in cellular mobility and the role of IPv6 in mobile computing.

5. What are the goals and assumptions of Mobile IP? Describe the entities and terminology involved in Mobile IP, and explain the process of IP packet delivery.

6. Discuss the procedures of agent advertisement, discovery, registration, and tunneling in Mobile IP, highlighting any optimizations used to improve performance.

7. Compare and contrast traditional TCP, indirect TCP, snooping TCP, and mobile TCP. How do these variants address the challenges of mobile computing?

8. Explain the enhancements made in mobile TCP, such as fast retransmit, fast recovery, transmission/time-out freezing, and selective retransmission, and how they improve the performance of TCP in mobile environments.

KU5DSECSE309 CLOUD, EDGE AND FOG COMPUTING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSE	300	KU5DSECSE309	4	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	0	1	50	50	100	2

Course Description:

"Cloud, Edge, and Fog Computing" is a comprehensive course aimed at exploring the transformative potential of distributed computing paradigms in the digital age. The course delves into the core concepts of Cloud Computing, elucidating its role as the backbone of modern IT infrastructure. The course introduces Edge Computing as a pivotal paradigm for reducing latency and enhancing responsiveness in distributed systems. The course provides the awareness about Fog Computing as an intermediate layer between the cloud and edge, facilitating decentralized data processing and analytics.

Course Objectives:

- Explore the need of new computing paradigms.
- To introduce concepts of Cloud, Edge and Fog Computing.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Obtain the knowledge about Cloud Computing.
CO2	To acquire knowledge on the concept of virtualization
CO3	Obtain the knowledge about Edge computing
CO4	To understand the concept of Fog Computing

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓		✓		✓
CO2	✓	✓		✓	
CO3	✓		✓		✓
CO4	✓		✓		✓

COURSE CONTENTS

Module 1: Introduction to Cloud Computing, Recent Trends in Computing Cloud Computing, Evolution of cloud computing. Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software, Security as a Service – Pros and Cons of cloud computing – Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices, Desktop Virtualization – virtual clusters and Resource Management – Virtualization for data center automation. (20 hours)

Module 2: Cloud Computing Architecture, Service Management in Cloud Computing Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Data Management in Cloud Computing, Resource Management in Cloud Computing, Cloud Implementation. (20 hours)

Module 3: Edge computing: Introduction - Relevant Technologies - Fog and Edge Computing Completing the Cloud - Hierarchy of Fog and Edge Computing - Business Models – Edge Computing Platforms -Opportunities and Challenges. (20 hours)

Module 4: Challenges in Federating Edge Resources, Case for Optimization in Fog Computing-Formal Modeling Framework for Fog Computing – Metrics - Further Quality Attributes - Optimization Opportunities along the Fog Architecture - Optimization Opportunities along the Service Life Cycle. (20 hours)

Module X: Case study on the Tools and Products available for Virtualization. Taxonomy of Optimization Problems in Fog Computing. (20 hours)

Core Compulsory Readings

1. Kai Hwang, Geoffery C. Fox and Jack J. Dongarra, “Distributed and Cloud Computing: Clusters, Grids, Clouds and the Future of Internet”, First Edition, Morgan Kaufman Publisher, an Imprint of Elsevier, 2012.
2. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley,2011.
3. Taheri J. & Deng S. (eds.): “Edge Computing: Models, technologies and applications”, IET, 2020

Core Suggested Readings

1. Gautam Shroff, Enterprise Cloud Computing - Technology, Architecture, Applications, Cambridge University Press, 2010.
2. Jason Venner, “Pro Hadoop- Build Scalable, Distributed Applications in the Cloud”, A Press, 2009
3. Al-Turjman F. (ed.): “Edge Computing: from hype to reality”, Springer,

   2019

4. Kris Jamsa, Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security and more, Jones & Bartlett Learning Company, 2013
5. R. Buyya, C. Vecchiola, S T. Selvi, Mastering Cloud Computing, Mc Graw Hill (India) Pvt Ltd., 2013

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab , Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses (4 Credit theory).

Sample Questions to test Outcomes.

1. What are the characteristics of Cloud Computing?
2. What is Cloud Storage?
3. What is Data Virtualization?
4. Write a short paragraph on Cloud Design Principles.
5. Write a paragraph on emerging trends in Cloud Computing.
6. Cloud computing service models arranged as layers in a stack. Explain the meaning of the statement.
7. What are the limitations of Cloud Computing?
8. What do you mean by Online File storage?

KU5DSECSE310 GEOGRAPHICAL INFORMATION SYSTEM

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	DSE	300	KU5DSECSE310	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

The course on Geographical Information System (GIS) provides an introduction to the principles and applications of spatial data analysis. Students will learn how to capture, store, manipulate, analyze, and visualize geographic data. The course covers topics such as data collection techniques, spatial database management, geospatial analysis, and cartographic design. Through hands-on exercises and projects, students will develop practical skills in utilizing GIS software and tools for solving real-world problems in various domains, such as urban planning, environmental management, and transportation logistics.

Course Objectives:

- To understand the fundamental principles and concepts of Geographical Information Systems (GIS).
- To gain proficiency in using GIS software for data manipulation, analysis, and visualization.
- To develop skills in collecting, managing, and organizing spatial data within a GIS environment.
- To apply geospatial analysis techniques to solve practical problems in fields such as urban planning, environmental sciences, and logistics.
- To acquire knowledge of cartographic design principles to effectively communicate spatial information through maps and visualizations.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Discuss in an informed way the techniques, terms and applications of GIS
CO2	Gather spatial information from various sources to include on a map
CO3	Use GIS to analyze and visualize spatial data to gain new knowledge
CO4	Collect, display, query, and analyze spatial and tabular data, and Produce maps that communicate a purpose and adhere to the principles of good map design.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to GIS, Defining GIS and Introduction to Spatial data, thematic characteristics of spatial data, sources of spatial data: census, survey data, air photos, satellite images, field data. Satellite Navigation Systems, Models of the Earth; Geoid and Ellipsoid, Datum and Projections, Spatial and attribute data modeling and Management: Spatial entities - Spatial data structures; Raster and Vector GIS implementation architecture; Desktop GIS, GIS Server, Web GIS applications (10 Hours)

Module 2: Free and Open-Source Software for GIS, Standards and Interoperability, Open Geospatial Consortium Web Map Servers- Web Feature Servers- Metadata standard, XML, Geographic Markup Language (15 Hours)

Module 3: Customization of GIS Overview- the need and benefit of Customization – programming for GIS applications - the enhancement of GIS functionalities through customization – Automation of redundant processes - Data development/update automation – Discuss various case studies that involve customization (20 Hours)

Module 4: Spatial databases, creating a spatially-enabled database, GIS objects, building spatial indexes, spatial queries and spatial functions, Building applications with spatial database, GIS Integration with R and Big Data. Web mapping, Web Mapping Services-Open Layers-Google Maps-Yahoo maps and Microsoft map services, Mashups. GeoRSS. Web GIS Implementation: Web Map servers and Data server (25 Hours)

Module X: Geospatial Analysis Techniques, Remote Sensing Integration, 3D GIS and Visualization, Spatial Data Mining and Machine Learning, Emerging Technologies and Future Directions (5 Hours)

Core Compulsory Readings

1. Heywood.L, Comelius.S and S. Carver, An Introduction to Geographical Information Systems, Dorling Kinderseley (India) Pvt. Ltd, 2006.
2. Burrough P A 2000 P A McDonnell, Principles of Geographical Information systems, London: Oxford University Press, 2000

Core Suggested Readings

1. Lo.C.P., Yeung. K.W. Albert, Concepts and Techniques of Geographic Information Systems, Prentice-Hall of India Pvt ltd, New Delhi, 2002.

2. Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W, Geographic Information Systems and Science. Chichester: Wiley. 2nd edition, 2005.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What are the thematic characteristics of spatial data, and how do they influence the analysis and interpretation of geographic information?
2. Explain the differences between raster and vector GIS data structures, and provide examples of scenarios where each would be most suitable for analysis.
3. Describe the role of Open Geospatial Consortium (OGC) standards in promoting interoperability among GIS software and data formats.
4. How does the use of XML and Geographic Markup Language (GML) facilitate the exchange and sharing of geospatial data between different GIS applications?
5. Why is customization important in GIS applications, and what are the benefits it offers in terms of enhancing functionality and efficiency.
6. Provide examples of how automation through customization can streamline redundant processes and improve data development/update workflows in GIS environments.

7. Explain the process of creating a spatially-enabled database and discuss the advantages of using spatial indexes for efficient spatial queries.
8. How can GIS be integrated with R and Big Data platforms to analyze large-scale geospatial datasets, and what are some potential applications of this integration in real-world scenarios?
9. What are some challenges and opportunities associated with the integration of remote sensing data with GIS, and how can this integration enhance the analysis of spatial phenomena such as land use classification and environmental monitoring?

Semester VI

KU6DSCCSE311 ANALYSIS AND DESIGN OF ALGORITHMS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSC	300	KU6DSCCSE311	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description: The objective of course is to impart theoretical knowledge in the specialized area of algorithm design and analysis. Study of algorithms is very substantial in classification of problems and their solutions based on complexity. Analysis of algorithms provides a means for choosing an appropriate algorithm for solving a problem at hand. The course provides an insight into all aspects of computational complexity and the use, design, analysis and experimentation of efficient algorithms. The better understanding paves way for successful implementations in various scientific applications. The course will focus on various advanced paradigms and approaches used to design and analyze algorithms.

Course Objectives:

- To introduce basic principles that drive various algorithm design strategies
- Discuss the Complexity Analysis Techniques
- Overview of P, NP Problems
- Discuss about the concept of Design and Analysis of Parallel Algorithms

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Accomplish Knowledge about important computational problems and acquire knowledge to design the algorithm.
CO2	Obtain knowledge to analyze algorithm control structures and solving recurrence.
CO3	Attain information about Complexity Classes
CO4	Accomplish knowledge about Parallel Algorithms

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Algorithm Design: Introduction, Steps in developing algorithm, Methods of specifying an algorithm, Decisions prior to designing: based on the capabilities of the device, based on the nature of solutions, based on the most suitable data structures. Important Problem Types: Sorting, Searching, String processing, Graph problems, Combinatorial problems, Geometric problems and Numerical problems. Basic Technique for Design of Efficient Algorithm: Brute Force approach (String matching), Divide-and-Conquer approach (Merge sort), Branch-and-Bound technique (Knapsack problem). Greedy approach (Kruskal's algorithm and Prim's Algorithm), Dynamic Programming (Longest Common Subsequence), Backtracking(Sum of subsets problem) (20 Hours)

Module 2: Algorithm Analysis: Importance of algorithm analysis, Time and Space Complexity. Growth of Functions: Asymptotic notations, Cost estimation based on key operations- Big Oh, Big Omega, Little Oh, Little Omega and Theta notations, Big Oh Ratio Theorem, Big Theta Ratio Theorem, Big Omega Ratio Theorem. Analyzing Algorithm Control Structures, Solving Recurrences: Iteration Method, Substitution Method, The Recursion Tree Method, Master's Theorem, Problem solving using Master's Theorem Case 1, Case 2 and Case 3. Analysis of Strasser's algorithm for matrix multiplication, Analysis of Merge sort (20 Hours)

Module 3: Complexity- Complexity Classes: P, NP, NP Hard and NP Complete problems. NP Completeness reductions for Travelling Salesman Problem and Hamiltonian Cycle. P versus NP problem (20 Hours)

Module 4: Design and Analysis of Parallel Algorithms: PRAM models – EREW, ERCW, CREW and CRCW, Relation between various models, Handling read and write conflicts, work efficiency, Brent's theorem. Analyzing Parallel Algorithms: Time Complexity, Cost, Number of Processors, Space Complexity, Speed up, Efficiency, Scalability, Amdahl's Law. Euler Tour Technique, Parallel prefix computation, Parallel merging and sorting (20 Hours)

Module X: Case study with examples (10 Hours).

Core Compulsory Readings

1. Thomas H Cormen, Charles E Leiserson, and Ronald L Rivest, Introduction to Algorithms, 3rd Edition, Prentice Hall of India Private Limited, New Delhi
2. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley
3. Pallaw, V K, Design and Analysis of Algorithms, Asian Books Private Ltd, 2012.
4. Razdan S, Fundamentals of Parallel Computing, Narosa Publishing House, 2014.

Core Suggested Readings

1. Pandey H M, Design and Analysis of Algorithms, University Science Press, 2013
2. Upadhyay, N, Design and Analysis of Algorithms, Sk Kataria & Sons, 2008.
3. U. Manber, Introduction to Algorithms: A Creative Approach, Addison Wesley,
4. Gilles Brassard and Paul Bratley, Fundamentals of Algorithmics, Prentice-Hall of India
5. Goodman S E and Hedetniemi, Introduction to the Design and Analysis of

Algorithms, Mcgraw Hill

6. Horowitz E and Sahni S, Fundamentals of Computer Algorithms, Galgotia Publications Pvt. Ltd

7. Oded Goldreich, P,NP and NP- Completeness, Cambridge University Press, 2011.

8. Donald Knuth, The Art of Computer Programming, Fundamental Algorithms,Volume- 1, Addison Wesley, 1997.

9. Sanjeev Arora and Boaz Borak, Computational Complexity- A Modern Approach, Cambridge University Press; 2009.

10. Daniel Hills W and Bruce M Boghosian, Parallel Scientific Computation, Science, Vol 261, Pp. 856-863

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes.

1. Differentiate Direct Recursion and Indirect Recursion.
2. Solve the recurrence **$T(n) = 2T(\sqrt{n}) + \log n$ 2.**
3. Let **$T(n) = 4\,T(n/2) + n^3$** , then show that **$f(n) = \Omega(n^3)$** and **$T(n) = \theta(n^3)$.**
4. Prove that Hamiltonian Cycle is NP Complete.
5. How can we solve Knapsack problem using Branch-and-Bound technique?
6. Given a set S = **{2, 4, 6}** and Weight = **6**. Find subset sum using backtracking approach.
7. Let **H(t)** be the number of multiplications in the following:

```
int Factorial( int t)
 {
   if (t = = 0)
```

then return 1

else

return **t*** Factorial(**t**-1)

}

Prove that **H(t) = t.**

8. 'The running time is directly proportional to the frequency count of the algorithm.' Explain the meaning of the statement in detail.

9. The recurrence $T(n) = 7T(n/2) + n^2$ describes the running time of an algorithm **A**. A competing algorithm **A'** has a running time of $T'(n)= kT'(n/4)+n^2$. What is the largest integer value for **k** such that **A'** is asymptotically faster than **A**?

10 . What do mean by Parallel Prefix Computation?

11. Can the master theorem be applied to the recurrence $T(n) = 2T(n/2) + n \log n$? Why or Why not?

KU6DSCCSE312 QUANTUM COMPUTING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSC	300	KU6DSCCSE312	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: Quantum computing is a rapidly advancing field that promises to revolutionize computation and problem-solving. This course provides an introduction to quantum computing tailored specifically for non-physics students. It covers the fundamental principles of quantum mechanics and explores how quantum phenomena can be harnessed to perform powerful computations. No prior knowledge of physics or advanced mathematics is required

Course Objectives:

- Understand the basic principles of quantum mechanics.
- Explore the fundamental concepts of quantum computing.
- Gain knowledge of quantum algorithms and their applications.
- Develop an understanding of quantum gates and quantum circuits.
- Explore the challenges and potential of quantum computing.
- Gain familiarity with quantum programming languages and frameworks.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Develop a foundational understanding of quantum mechanics and its relevance to computing.
CO2	Gain knowledge of quantum algorithms and their potential applications.
CO3	Acquire practical skills in quantum programming and working with quantum circuits.
CO4	Understand the challenges and future directions in quantum computing research.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Quantum Mechanics -Overview of classical computing and its limitations -Introduction to quantum mechanics -Wave-particle duality-Superposition and measurement-Quantum entanglement (10 Hours)

Module 2: Quantum Computing Basics -Introduction to qubits and quantum gates -Quantum states and quantum operations - Quantum circuits and circuit model of Computation-Measurement and quantum measurement postulate (15 Hours)

Module 3: Quantum Algorithms-Quantum parallelism and superposition - The Deutsch-Jozsa algorithm - Grover's algorithm for unstructured search -Shor's algorithm for factoring large numbers (20 Hours)

Module 4: Quantum Simulators and Hardware- Overview of quantum simulators and their role in quantum computing research Introduction to quantum hardware (e.g., qubits, quantum gates) - Comparison of different quantum computing technologies (e.g., superconducting qubits, trapped ions) - **Quantum Programming Languages and Frameworks**- Introduction to quantum programming languages (e.g., Q#, Qiskit) - Basics of quantum program structure and execution - Quantum gates and operations in programming languages - Hands-on exercises using quantum programming frameworks (20 Hours)

Module X :

Advanced Quantum Computing

- Quantum Fourier transform and its applications
- Shor's factorization algorithm and quantum cryptography
- Quantum simulation and quantum machine learning
- Introduction to quantum error correction

Quantum Computing Applications

- Quantum computing in cryptography and secure communication
- Quantum optimization and quantum annealing
- Quantum simulation of physical systems
- Potential impact of quantum computing on various industries

Programming Quantum Computers

- Introduction to quantum software development kits (SDKs)
- Quantum programming languages: Qiskit, Cirq, and PyQuil
- Building and running quantum circuits (10 Hours)

Core Compulsory Readings

1. Quantum Computing for Everyone" Author: Chris Bernhardt Publisher: The MIT Press Year: 2019

Core Suggested Readings

1. Programming Quantum Computers: Essential Algorithms and Code Samples" by Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia (O'Reilly Media)
2. Quantum Computing for Computer Scientists" by Noson S. Yanofsky and

Mirco A. Mannucci (Cambridge University Press)

3. Quantum Computing: An Applied Approach" by Jack D. Hidary (Springer)

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What is a qubit in quantum computing and how is it different from a classical bit?
2. What is superposition in quantum computing and why is it important for quantum algorithms?
3. Explain the concept of entanglement in quantum computing and its significance in quantum communication and computation.
4. Describe the fundamental difference between quantum gates and classical logic gates, and provide an example of a commonly used quantum gate.
5. Compare and contrast quantum computing with classical computing. Highlight at least three key differences between the two.
6. Explain the concept of quantum algorithms and provide an overview of an important quantum algorithm, such as Shor's algorithm or Grover's algorithm.

KU6DSCCSE313 THEORY OF COMPUTATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSC	300	KU6DSCCSE313	4	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	0	1	50	50	100	2

Course Description:

This course introduces fundamental concepts in theoretical computer science, focusing on the study of formal models of computation and their properties. Topics include automata theory, formal languages, computability theory, and complexity theory.

Course Objectives:

- Introduce the theoretical foundations of computation.
- Familiarize formal models of computation such as finite automata, regular expressions, context-free grammars, Turing machines, etc.
- Explore the concepts of decidability and undecidability.
- Familiarize the hierarchy of computational complexity classes and their properties

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the concepts of regular expression, DFA, and NFA.
CO2	Explore the concepts of context-free grammar, push down automata, and how they help in language parsing.
CO3	Explore the concepts of turning machines which will provide insights into the design and analysis of algorithms.
CO4	Understand fundamental concepts of computability such as decidability and undecidability.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Introduction to Automata Theory: Deterministic finite automata (DFA), Nondeterministic finite automata (NFA), Regular expressions, Equivalence of DFA, NFA, and regular expressions (10 Hours)

Module 2: Context-Free Languages and Grammars: Context-free grammars (CFG), Pushdown automata (PDA), Relationship between CFG and PDA, Parsing techniques (15 Hours)

Module 3: Turing Machines: Definition and examples, Variants of Turing machines, Universal Turing machines, Turing machine equivalents of other models of computation (15 Hours)

Module 4: Computability Theory: Church-Turing thesis, Halting problem and undecidability, recursively enumerable languages, Post correspondence problem (10 Hours)

Module X : Complexity Theory: Time and space complexity, Polynomial-time algorithms and NP-completeness, Cook-Levin theorem, P versus NP problem (10 Hours)

Core Compulsory Readings

1. An introduction to Formal Languages and Automata, Peter Linz, 4th edn, Narosa Publishing House.
2. "Automata Theory, Languages, and Computation" by John E. Hopcroft, Rajeev Motwani, and Jeffrey D. Ullman
3. John C Martin, Introduction to Languages and the Theory of Automata, McGraw Hill 1997
4. Mishra & Chandrasekharan, Theory of Computer Science: Automata, Languages and Computation, 3rd edition, PHI

Core Suggested Readings

1. "Introduction to the Theory of Computation" by Michael Sipser

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. What is Automata? What are different types of it?
2. Differentiate between empty and non empty languages
3. Expressive power of a Push down automata is 2. Why?
4. Differentiate between clean closure and positive closure. Why clean closure is considered as a universal language with respect to a particular alphabet.
5. Construct a minimal FA that accepts all the strings of a's and b's where every string starts with ba. ∑={a,b}
6. Construct a regular expression that generate all the strings of a's and b's where every string starts and ends with different symbols.

S6 - List of Discipline Specific Electives (DSE) (POOL E)

KU6DSECSE314 INTERNET OF THINGS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE314	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course introduces the fundamentals of the Internet of Things (IoT), covering its definition, significance, current technology trends, various IoT protocols, and the relationship between IoT, cloud computing, and fog computing.

Course Objectives:

- To understand the definition and significance of the Internet of Things.
- To gain insights about the current trends associated with IOT technologies.
- To build a conceptual understanding of basic Arduino programming.
- To promote awareness regarding various protocols used in IoT.
- To explore the relationship between IoT, cloud computing and fog computing.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamentals of the Internet of Things and its building blocks along with their characteristics and its domain.
CO2	Learn the architecture, operation, and business benefits of an IoT solution.
CO3	Understand various protocols, and emerging computing paradigms in IoT.
CO4	Understand cloud computing and it importance for building IoT applications

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✓	✔
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Introduction to The Internet of Things: IoT Definition, Elements of an IoT ecosystem, IoT applications, trends and implications, Major components of IOT(Hardware & Software). **IoT Sensing and Actuation:** Introduction, Sensors, Sensor Characteristics, Sensorial Deviations, Sensing Types, Sensing Considerations, Actuators, Actuator Types, Actuator Characteristics. **Introduction to Arduino Programming**: Integration of Sensors and Actuators with Arduino programming

Module 2: IoT Architecture and Communication: Protocol Layered Architecture for IoT, Protocol Architecture of IoT, Infrastructure Protocols: MAC protocols for sensor network, S-MAC, IEEE 802.15.4, Near Field Communication (NFC), RFID, ZigBee, Bluetooth Low Energy (BLE), IPv6 over LowPower Wireless Personal Area Networks (6LoWPAN), Long Term Evolution-Advanced, Z-Wave, Components of ZWave Network, **Protocols for IoT Service Discovery**: DNS service discovery, multicast domain name system.

Module 3: IoT Networking Protocol: Constrained Application Protocol (CoAP), Message Queue Telemetry Transport (MQTT), Extensible Messaging and Presence Protocol (XMPP), Advanced Message Queuing Protocol (AMQP), Data Distribution Service (DDS), Service Discovery Protocols, Routing Protocol for Low Power and Lossy Networks (RPL), sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, sensor network architecture, data dissemination and gathering protocol.

Module 4: Cloud Computing: Introduction, Virtualization, Cloud Models, Service-Level Agreement in Cloud Computing, Cloud Implementation, Sensor-Cloud: Sensors-as-a-Service, **fog computing.**

Module X :

The IoT Data Analytics Platforms: IBM Watson IoT Platform, Splunk Software for IoT Data, Amazon Web Service IoT Platform, Azure IoT Hub, The IoT Data Virtualization Platforms, IoT Data Visualization Platform, Security and Privacy in IoT.

IoT Case Study: Agriculture, Healthcare, Process Automation & monitoring etc.

Core Compulsory Readings

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy, "Introduction to IoT", Cambridge University Press 2021

2. Pethuru Raj and Anupama C. Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
3. Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, “Internet of Things: Architectures, Protocols and Standards,” Wiley, 2018.

Core Suggested Readings

1. Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, “Internet of Things: Architectures, Protocols and Standards,” Wiley, 2018.
2. Fei Hu, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations,” CRC Press, 2016.
3. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”,1st Edition, VPT, 2014.
4. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015 3. Editors Ovidiu
   Vermesan
5. 2. Peter Friess,'Internet of Things – From Research and Innovation to Market Deployment', River Publishers, 2014
6. Fei Hu, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations,” CRC Press, 2016.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture and Lab, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. Define the Internet of Things (IoT) and explain its significance in modern technology. How does IoT extend the capabilities of traditional internet-connected devices?
2. Describe different types of sensors commonly used in IoT applications. What are the characteristics that make sensors suitable for IoT deployments?
3. Explain the integration of sensors and actuators with Arduino programming. How does Arduino facilitate the connection and control of hardware components in IoT projects?
4. Discuss about MAC protocols for sensor networks?
5. Explain the components of a Z-Wave network and how they interact to enable communication between devices in a smart home or building automation system.
6. Explain the role of Message Queue Telemetry Transport (MQTT) in IoT communication. How does MQTT facilitate efficient and reliable messaging between IoT devices and servers?
7. Discuss the Advanced Message Queuing Protocol (AMQP) and its benefits for IoT messaging. How does AMQP ensure interoperability and scalability in distributed IoT deployments?
8. Explain the Routing Protocol for Low Power and Lossy Networks (RPL) and its significance in IoT sensor networks. How does RPL address the unique constraints and challenges of constrained environments?
9. Explore the concept of Sensor-Cloud and its significance in IoT applications. How does Sensors-as-a-Service (SaaS) leverage cloud computing to enhance sensor data processing and analysis?
10. Explain the concept of fog computing and its advantages over traditional cloud computing for IoT applications at the network edge.

KU6DSECSE315 BIG DATA ANALYTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE315	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course provides students with an overview of the fundamental concepts, technologies, and tools associated with big data. This course deals with the importance of Big Data, Stream Data Model in Big Data, Big Data Analytics, and Hadoop Distributed File System

Course Objectives:

- Understand the Big Data Platform and its application.
- Illustrate different types of big data technologies in the Hadoop parallel world.
- Demonstrate the concepts in Hadoop, Map Reduce, HDFS for application development.
- Familiarize the basic methodologies of pig and hive.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO 1	Understand Big Data, its importance, challenges, and various sources of data.
CO 2	Familiarize the fundamental concepts of streams and real-time analysis.
CO 3	Understand the components of Hadoop and Hadoop Eco-System and apply them in developing solutions for Big Data analysis.
CO 4	Familiarize the applications on Big Data using Pig and Hive.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	✔	✔	✔	✔	✔
CO 2	✔	✔	✔	✔	✔
CO 3	✔	✔	✔	✔	✔
CO 4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis –Nature of Data - Analytic Processes and Tools - Analysis vs Reporting - Modern Data Analytic Tools -Statistical Concepts:

Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error. (20 hours)

Module 2: The Hadoop Distributed File System – Components of Hadoop Analyzing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS-Java interfaces to HDFS Basics-Developing a Map Reduce Application, How Map Reduce Works-Anatomy of a Map Reduce Job Run-Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats - specification (20 hours)

Module 3: Cluster Setup and Installation – Hadoop Configuration-Security in Hadoop - Administering Hadoop – HDFS - Monitoring-Maintenance- Hadoop benchmarks- Hadoop in the cloud. Map Reduce Features. Setting up a Hadoop Cluster (20 hours)

Module 4: Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive – fundamentals of HBase and Zookeeper - IBM InfoSphereBigInsights and Streams. Visualizations -Visual data analysis techniques, interaction techniques, Systems and applications. (20 hours)

Module X (Teacher Specific): : Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform (RTAP), Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions.(10 hours)

Core Compulsory Readings

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Tom White, Hadoop: The Definitive Guide, 3rdEdn, O'reily Media, 2012.

Core Suggested Readings

1. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, Understanding BigData: Analytics for Enterprise Class Hadoop and Streaming Data, McGraw-Hill Pub, 2012
2. AnandRajaraman & Jeffrey D Ullman, Mining of Massive Datasets, Cambridge
   University Press,2012
3. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & Sons, 2012
4. Glen J. Myyat, Making Sense of Data, John Wiley & Sons, 2007
5. Pete Warden, Big Data Glossary, O'Reily, 2011

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. Explain the core components of Hadoop.
2. What is Big Data, and where does it come from?
3. Can you explain the concept of the "three Vs" of big data?
4. What are some common challenges associated with processing and analyzing big data?
5. Can you explain the MapReduce programming model and its role in distributed computing?

KU6DSECSE316 VIRTUAL AND AUGMENTED REALITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE316	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course offers a comprehensive exploration of the domains of virtual reality (VR) and augmented reality (AR). Comprising five detailed modules, the curriculum delves into the fundamental concepts, theoretical underpinnings, and integration of various sensory inputs. Moreover, it provides an exploration of foundational concepts and tools related to AR.

Course Objectives:

- To give a comprehensive knowledge on the historical and new perspectives of VR and AR.
- To provide an in-depth comprehension of the foundational aspects and mathematical frameworks of VR and AR.
- To familiarize with the latest progressions and technological advancements within these fields.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamentals of VR, its historical context, hardware and software, and various application domains of VR and AR.
CO2	Gain knowledge of the challenges inherent in VR, such as latency, hardware limitations, navigation issues, and health concerns.
CO3	Familiarize the geometric principles, the fundamentals of light and optics, and visual perception for designing and developing VR.
CO4	Develop an understanding of the audio perception in VR, and visual rendering which specifies what the visual display should show through an interface.
CO5	Know in detail about the fundamentals and applications of AR systems and technologies, along with motion, tracking, and interaction design techniques within VR environments.
CO6	Develop an understanding of the evaluation fundamentals to build better VR systems and experiences, advanced technologies for future VR and AR, and tools and platforms for AR.

Mapping of COs to PSOs

	PSO 1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✔	✔	✔	✔	✔
CO5	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: *Introduction to Virtual Reality:* Introduction – Definition of VR, History of VR; VR Hardware and Software - sensors, displays (CAVE and HMDs), virtual world generator, game engines; Human physiology and perception; Presence and immersion in VR; VR Applications. Challenges in VR - latency, hardware challenges, navigation, motion sickness, other health issues. (20 hours)

Module 2: *Geometry of Virtual Worlds:* Geometric modelling; Transforming models; Matrix algebra and 2D rotations; 3D rotations and yaw, pitch, and roll; Axis-angle representations; Quaternions; Homogeneous transforms; Eye transforms; Canonical view transform; Viewport transform.

Optics and Visual Perception in VR: Optics - Light propagation, refraction, lenses, optical aberrations, human eye, cameras and displays; Physiology of Vision - the human eye, photoreceptors and densities, eye movements, implications for VR; Visual perception - depth perception, motion perception, colour perception, frame rates and displays.(20 hours)

Module 3: *Audio in VR:* Physics of sound and ear physiology; auditory perception; auditory localization; Rendering.

Visual Rendering: Visual rendering; Ray tracing and shading; Rasterization; Pixel shading; VR rendering problems; anti-aliasing; Distortion shading; post-rendering image warp. (20 hours)

Module 4: *Motion in VR, Tracking, and Interaction:* Motion - motion in real world, vestibular system, physics of motion in virtual world; Tracking - orientation tracking, tilt drift correction, yaw drift correction, tracking with a camera, perspective n-point problem, filtering, lighthouse approach; Interaction - overview of interfaces, locomotion, manipulation, social interaction.

Augmented Reality: Introduction to AR; The Basics of AR Functionality; AR applications; Working of AR and Concepts of AR; AR hardware – sensors, processors, displays, and AR systems; AR software; AR content – visual content, audio content, content for other senses (touch, taste, and smell); Interaction in AR – real world interaction, manipulation, navigation, communication, interaction in projected AR environments. (20 hours)

Module X :

Evaluating VR Systems and Experiences: Perceptual training; Recommendations for developers and best practices; VR sickness; Experimental methods that involve human subjects. (10 hours)

Advanced Technologies for VR: Touch and Haptics; Taste and smell; Robotic interfaces; Telepresence; Brain-machine interfaces.

AR, Tools, Platforms, and Fundamentals: Mobile augmented reality; AR development tools and platforms – Unity3D, AR software development kits, ARToolkit, ARCore; Setting Up Unity 3D for AR; AR Fundamentals in Unity 3D.

Core Compulsory Readings

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2023.
2. Foundations of Sensation and Perception (2nd Edition), Mather, G, Psychology Press, 2009.
3. Fundamentals of Computer Graphics (3rd Edition), Shirley, P., Ashikhmin, M., & Marschner, S. A K Peters/CRC Press, 2009.
4. The VR book: Human-centered design for virtual reality, Jerald, J, Morgan & Claypool, 2015.
5. Understanding augmented reality: Concepts and applications, Craig, A. B, Morgan Kaufmann Publishers, 2013.

Core Suggested Readings

1. 3D User Interfaces: theory and practice, LaViola Jr, J. J., Kruijff, E., McMahan, R. P., Bowman, D., & Poupyrev, I. P, AddisonWesley, 2005.
2. Handbook of virtual environments: Design, implementation, and applications, Hale, K. S., & Stanney, K. M. (Eds.), CRC Press, 2015

3. Augmented reality with unity AR foundation: a practical guide to cross-platform AR development with Unity 2020 and later versions, Linowes, J, Packt Publishing Ltd, 2021
4. Mastering Augmented Reality Development with Unity Create Immersive and Engaging AR Experiences with Unity, Indika Wijesooriya, BPB Publications, 2023

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes.

1. Discuss about VR displays CAVE and HMD.
2. Explain the structure and working of human eye.
3. What is presence and immersion in VR, and how are they achieved?
4. Discuss different ways to represent rotations?
5. Explain viewport transformation.
6. How does visual perception impact VR experiences, particularly in terms of depth perception, motion perception, and frame rates?
7. Explain distortion shading and post-rendering image warp in the context of VR.
8. What is Augmented Reality (AR) and discuss its basic functionality.
9. Describe the hardware, software, and interaction aspects of AR systems.
10. Discuss the concept of VR sickness and various strategies to mitigate it.

KU6DSECSE317 GAME DEVELOPMENT

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE317	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: Embark on a journey into the dynamic world of game development with our comprehensive course. Designed for both beginners and enthusiasts alike, this course offers a holistic understanding of the game development process. From foundational concepts in design and programming to advanced techniques in graphics, networking, and AI, students will gain hands-on experience using industry-standard tools such as Unity. Through a blend of theory, practical exercises, and project-based learning, participants will emerge equipped with the skills and knowledge necessary to bring their game ideas to life across various platforms. Whether aspiring to join the thriving game industry or simply seeking to unleash their creativity, this course provides a solid foundation for all game development enthusiasts.

Course Objectives:

- Provide a comprehensive understanding of game development fundamentals, tools, and trends.

- Develop proficiency in game design, prototyping, and development using Unity and other industry-standard tools.
- Explore advanced concepts like scripting, AI, multiplayer networking, and optimization techniques.
- Foster hands-on, project-based learning to apply acquired skills and build a strong portfolio for real-world scenarios.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Gain a solid grasp of game development fundamentals, tools, and trends.
CO2	Become proficient in game design, prototyping, and development using industry-standard tools like Unity.
CO3	Master advanced concepts including scripting, AI, multiplayer networking, and optimization techniques
CO4	Build a strong portfolio, preparing them for real-world scenarios and enhancing employability in the game industry.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓			✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Game Development

Overview of game development: history, trends, and current landscape, Basics of game design principles, Introduction to game engines and their importance, understanding game assets: graphics, sound, and music, Basics of programming languages commonly used in game development (e.g., C#, C++, Java) (15 hours)

Module 2: Game Design and Prototyping

Deep dive into game design: mechanics, dynamics, and aesthetics, Prototyping techniques and tools, User experience (UX) and user interface (UI) design for games, Playtesting and iteration, Introduction to version control systems for collaborative development (e.g., Git), Assignment: Create a prototype of the game designed in Module 1 and conduct playtesting sessions for feedback. (15 hours)

Module 3: Game Development with Unity

Introduction to Unity game engine, Understanding Unity's interface and workflow, Scene creation and management, Scripting in C# for game logic, Implementing player controls and interactions, Introduction to 2D and 3D game development in Unity, (15 hours)

Module 4: Advanced Game Development Concepts

Advanced scripting and programming techniques in Unity, Working with physics and animations, Implementing artificial intelligence (AI) for non-player characters (NPCs), Multiplayer game development concepts and networking, Optimizing games for performance and scalability, Publishing games on various platforms (PC, mobile, console) (15 hours)

Module X: Advanced graphics programming: shaders, lighting, and post-processing effects, Procedural content generation (PCG) techniques for creating dynamic and varied game worlds, Introduction to virtual reality (VR) and augmented reality (AR) game development, Advanced networking and multiplayer synchronization techniques, Integrating machine learning for AI behavior and procedural generation, Performance optimization strategies for resource-intensive games(15 hours)

Core Compulsory Readings

1. Book: "Game Design Workshop: A Playcentric Approach to Creating Innovative Games" by Tracy Fullerton
2. Book: "The Art of Game Design: A Book of Lenses" by Jesse Schell

Core Suggested Readings

1. Book: "Unity in Action" by Joe Hocking
2. Book: "Game Programming Patterns" by Robert Nystrom
3. Book: "Real-Time Rendering" by Tomas Akenine-Möller, Eric Haines, Naty Hoffman
4. Book: "Game AI Pro" edited by Steve Rabin

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What are some key historical milestones in the evolution of game development?
2. How do game design principles contribute to creating engaging and immersive gaming experiences?
3. Why are game engines essential for modern game development, and what are some popular examples?
4. Can you explain the role of graphics, sound, and music in enhancing the player's experience in a game?
5. What programming languages are commonly used in game development, and how do they differ in their application?
6. How does game prototyping contribute to the iterative design process, and what are some prototyping techniques and tools?
7. What is the significance of user experience (UX) and user interface (UI) design in game development, and how do they impact player engagement?
8. How does version control system usage, such as Git, facilitate collaborative game development projects?
9. What are the main components of the Unity game engine, and how do they contribute to the game development workflow?
10. Can you explain the differences between 2D and 3D game development in Unity, and provide examples of each?

KU6DSECSE318 WEARABLE COMPUTING AND SENSORS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE318	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course provides a comprehensive understanding of wearable computing technology and Body Sensor Networks, as well as the basic principles of different sensors and actuators.

Course Objectives:

- To explore Wearable components and building blocks of Wearable Computing.
- To enumerate the details of Body Sensor Networks (BSN).
- To create a conceptual understanding of the basic principles of sensors, actuators, and their operations.
- To understand various types of sensors, actuators, transducers and its application.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Learn about software, hardware tools, protocols and components required for Wearable Computing.
CO2	Understand the basics of Body Sensor Networks (BSN) and its Programming Framework.
CO3	Classify different Sensors & Actuators based on various physical phenomena and differentiate their performance characteristics.
CO4	Understand the working principle of special-purpose sensors and the need for developing smart sensors.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Introduction to Wearable Components: History - Internet of Things and Wearables - Wearables' Mass Market Enablers - Human Computer Interface and Human Computer Relationship - A Multi Device World, Role of Wearables, Attributes of Wearables (15 hours)

Building Blocks for Wearable Computing: Bluetooth Low Energy (BLE) - Embedded Software Programming - Sensors for Wearables - Android Wear:

Notification Settings and Control, Wear Network - Android Wear API: DataItem – DataMapItem – DataMap - Google Fit API: main package - data sub package.

Module 2: Body Sensor Networks: Typical m-Health System Architecture - Hardware Architecture of a Sensor Node - Communication Medium - Power Consumption Considerations - Communication Standards - Network Topologies - Commercial Sensor Node Platforms - Bio-physiological Signals and Sensors - BSN Application Domains - Developing BSN Applications - Programming Abstractions - Requirements for BSN Frameworks - BSN Programming Frameworks (15 hours)

Signal Processing In-Node Environment: Introduction,Background,Motivations and Challenges, The SPINE Framework, Architecture, Programming Perspective-Optional SPINE Modules, High-Level Data Processing (15 hours)

Module 3: Overview of Sensors and Actuators: Definitions: Sensors & Actuators – Overview of Sensor and Actuator classifications – Performance characteristics of Sensors & Actuators.

Smart Sensors and Applications: Integrated and Smart sensors, IEEE 1451 standard & Transducer Electronic Datasheets (TEDs), Overview of various smart sensors: Digital temperature sensor (DS1621, TMP36GZ), Humidity sensor (DHT11, DHT22, FC28), IR sensor (FC51), Gas sensor (MQ2,MQ8), Pressure sensors (BMP180), Accelerometers (ADXL335), etc; Structural health monitoring sensors, Introduction to MEMSand Flexible sensors. (15 hours)

Module 4: Sensors and Transducers: Thermoelectric sensors, piezoelectric sensors, pyroelectric sensors, photovoltaic sensors, electrochemical sensors, Wearable applications: temperature sensitive fabric, electrochemical sensors. Resistive sensors- Potentiometers, strain gages (piezo-resistive effect), resistive temperature detectors (RTD), thermistors, magnetoresistors, light dependent resistor (LDR), resistive hygrometers, resistive gas sensors. Wearable applications: Strain sensor for monitoring Physiological signals, body movement.

Mechanical Transducers: Accelerometers: Characteristics and working principle, Types- Capacitive, Piezoresistive, piezoelectric; Gyroscopes: Characteristics and working principle, Rotor Gyroscope; Diaphragm Pressure Sensor –resistive & capacitive type (micro press sensor). Wearable applications: Motion sensors for fall detection, hemiplegic and PD (Parkinson's disease) patients. (15 hours)

Module X:

Autonomic BSN, Agent-Oriented BSN , Collaborative BSN, Interation of wearable and cloud computing. (15 hours)

Core Compulsory Readings

1. Sanjay M. Mishra, Wearable Android™: Android wear & Google Fit app development, 2015, 1st edition, John Wiley & Sons, USA
2. Fortino, Giancarlo, Raffaele Gravina, and Stefano Galzarano, Wearable computing: from modelling to implementation of wearable systems based on body sensor networks, 2018, 1st edition, John Wiley & Sons, USA
3. Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", 2016, 5th Edition, Springer, Switzerland.
4. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications" Elsevier, 2014

Core Suggested Readings

1. Barfield, Woodrow, ed. Fundamentals of wearable computers and augmented reality, 2015, 1st edition, CRC press, USA
2. Nathan Ida, "Sensors, Actuators and their Interfaces - A Multidisciplinary Introduction", 2020, 2nd Edition, IET, United Kingdom.
3. Subhas Chandra Mukhopadhyay, Octavian Adrian Postolache,

Krishanthi P. Jayasundera, Akshya K. Swain, "Sensors for Everyday Life Environmental and Food Engineering", 2017, Volume 23, Springer, Switzerland.

4. Volker Ziemann, "A Hands-On Course in Sensors Using the Arduino and Raspberry Pi", 2018, 1st Edition, CRC Press, United States.
5. Jon. S. Wilson, "Sensor Technology Hand Book", Elsevier Inc., 2005.
6. Subhas C. Mukhopadhyay, "Wearable Electronics Sensors-For Safe and Healthy Living", Springer International Publishing, 2015.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. Describe the role of Bluetooth Low Energy (BLE) in wearable computing. What advantages does it offer over traditional Bluetooth?
2. Discuss bio-physiological signals commonly monitored in BSNs and the sensors used to capture them. Provide examples of applications for each type of signal.
3. Describe the SPINE framework for signal processing in node environments. What are its key architectural components?
4. Discuss the performance characteristics that are commonly used to evaluate sensors and actuators. Why are these characteristics important in their selection and application?

5. Explain the IEEE 1451 standard and its significance in the development and interoperability of smart sensors. How do Transducer Electronic Datasheets (TEDs) contribute to standardization?
6. Describe its operation, key specifications, and potential applications of Humidity sensor DHT11, DHT22, FC28
7. Discuss the application of pyroelectric sensors in detecting infrared radiation. What are some typical applications of pyroelectric sensors in various industries?
8. Explain the working principle of gyroscopes. How do they detect angular motion, and what are their main characteristics?
9. Explore the use of motion sensors, including accelerometers and gyroscopes, in wearable devices for fall detection and monitoring patients with conditions such as hemiplegia and Parkinson's disease. How do these sensors contribute to improving patient safety and healthcare outcomes?
10. Provide an overview of electrochemical sensors and their role in detecting various substances. What are some examples of electrochemical sensors used in environmental monitoring and healthcare?

KU6DSECSE319 COMPUTATIONAL PHOTOGRAPHY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE319	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course "Computational Photography" explores the fusion of photography and computer science, focusing on innovative techniques to enhance, manipulate, and analyze digital images. Beginning with foundational concepts, it covers image enhancement, segmentation, deep learning, and applications in diverse fields. Additionally, the course addresses ethical considerations. Through theoretical instruction and hands-on projects, students gain skills for careers in visual effects, virtual reality, and computer vision.

Course Objectives:

- Provide a comprehensive understanding of computational photography techniques for enhancing digital images.
- Introduce advanced concepts such as image segmentation and deep learning for image processing.
- Explore applications of computational photography in various fields, including medicine and remote sensing.
- Address ethical considerations and social implications related to computational photography practices.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Proficiency in applying computational photography techniques to enhance and manipulate digital images effectively.
CO2	Mastery of advanced concepts such as image segmentation and deep learning for image processing.
CO3	Ability to utilize computational photography methods in diverse applications such as medical imaging and remote sensing.
CO4	Awareness of ethical considerations and social implications associated with computational photography practices.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: **Fundamentals of Computational Photography:** Introduction to computational photography: Definition, history, and significance. Basic concepts in digital imaging: Image formation, sensors, and image processing. Image enhancement techniques: Noise reduction, sharpening, and contrast adjustment. Computational photography algorithms: HDR imaging, panorama stitching, and image stacking. (15 hours)

Module 2: Advanced Image Processing Techniques: Image segmentation and object detection: Algorithms for identifying and isolating objects in images.

Image fusion and blending: Techniques for combining multiple images to enhance visual quality. Content-aware image manipulation: Tools and algorithms for intelligent image editing. Deep learning for image processing: Introduction to convolutional neural networks and their applications in image processing. (15 hours)

Module 3: Computational Photography Applications: Computational imaging for mobile devices: Overview of smartphone camera technologies and their computational photography features. Computational photography in computer vision: Applications in augmented reality, object recognition, and scene understanding. Computational photography in medical imaging: Techniques for image enhancement, segmentation, and analysis in medical imaging applications. Computational photography in remote sensing: Applications in satellite imaging, environmental monitoring, and agriculture. (15 hours)

Module 4: Ethical and Social Implications of Computational Photography: Privacy and surveillance issues: Ethical considerations related to image capture, processing, and sharing. Bias and fairness in computational photography algorithms: Challenges and solutions for ensuring fairness and inclusivity. Creative manipulation and authenticity: Discussion on the impact of computational techniques on the authenticity of visual content. Regulatory frameworks and guidelines: Overview of existing regulations and guidelines governing computational photography practices.(15 hours)

Module X:

Computational Photography for Visual Effects and Virtual Reality: Introduction to visual effects (VFX) and virtual reality (VR) technologies. Techniques for image-based rendering and scene reconstruction in VFX and VR applications. Advanced image manipulation algorithms for creating realistic visual effects. Deep learning approaches to image synthesis and generation for VFX and VR. Computational photography in immersive storytelling and interactive experiences. Case studies and applications of computational photography in the film industry and VR content creation. (15 hours)

Core Compulsory Readings

1. Szeliski, R. (2010). Computer vision: Algorithms and applications. Springer Science & Business Media.
2. Forsyth, D. A., & Ponce, J. (2012). Computer vision: A modern approach. Prentice Hall.
3. Lu, J., & Shao, L. (2014). Perceptual computing: Aiding people in making subjective judgments. Springer.
4. Jacobs, C. E. (2018). Ethics in Computational Photography (1st ed.). MIT Press.

Core Suggested Readings

1. Grossberg, M. D. (2017). Data Acquisition Techniques Using PCs (2nd ed.). Academic Press.
2. Togelius, J., Yannakakis, G. N., Stanley, K. O., & Browne, C. (2018). Artificial Intelligence and Games (1st ed.). Springer.
3. Smith, W. A. (2019). Principles of 3D Image Analysis and Synthesis (1st ed.). Springer.
4. Elgammal, A., & Elhoseiny, M. (2020). The AI Renaissance: Essays on Artificial Intelligence and Its Implications (1st ed.). Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What is the role and significance of computational photography in modern imaging technology?
2. Explain the basic concepts of digital imaging and image processing in computational photography.
3. How do image segmentation algorithms work, and what are their applications in computational photography?
4. Discuss the utilization of deep learning methods for image enhancement and manipulation.
5. Describe the application of computational photography techniques in medical imaging.
6. How can computational photography be utilized in remote sensing applications?
7. What are the ethical considerations related to the use of computational photography techniques?
8. Discuss the potential social implications of widespread adoption of computational photography practices.

KU6DSECSE320 DESIGN THINKING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	DSE	300	KU6DSECSE320	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE duration : 2 hours for theory and 3 hours for Lab**

Course Description: The course provides an introduction to Design Thinking, a human-centered problem-solving methodology used to address real-world challenges and create innovative solutions. Through lectures, discussions, activities, case study discussions, and exploration of various tools and methodologies, students will gain a deeper understanding of design thinking's core principles and its practical application.

Course Objectives:

- Impart knowledge on design thinking, process and mindsets
- Impart knowledge on problem space and solution space
- Familiarize various tools and methodologies used as part of design thinking process.
- Impart knowledge on product design, design sprints.
- Familiarize with real world case studies where design thinking has been applied.

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the basics of design thinking process and mindsets
CO2	Utilize various tools and methodologies for user research, problem definition, and ideation
CO3	Define problems effectively, identify user needs, generate creative solutions, prototype and test ideas to gather user feedback
CO4	Apply design thinking to address real-world challenges

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Design Thinking: foundations, mindsets, process (empathize, define, ideate, prototype, test), benefits and applications Case studies of successful design thinking projects. (20 hours)

Module 2: Understanding the Problem Space: User research methods - interviews (in-depth, contextual), surveys (open-ended, closed-ended), observations (ethnographic, contextual inquiries). Building user empathy - empathy mapping, customer journey mapping, ecosystem mapping, actor mapping, personas. Identifying and Prioritizing User Needs: 5 Whys analysis, Kano model, user story writing. Problem Definition and Framing: "How-might-we" questions. (20 hours)

Module 3: Exploring the Solution Space: Ideation techniques - brainstorming, brainwriting, worst possible idea, SCAMPER Refining Ideas: crazy 8s, design critiques, affinity diagramming Rapid Prototyping Principles and Techniques: Low-fidelity (paper, cardboard), medium-fidelity (digital tools), high-fidelity (advanced digital tools) User Testing and Feedback Iteration: Usability testing techniques, A/B testing, user feedback analysis (20 hours)

Module 4: Design Thinking in Action: Product Design - User experience (UX) design principles, Information architecture (IA), Design for manufacturability Design Sprints and Other Rapid Innovation Methods: Design sprint framework, Lean Startup methodologies (20 hours)

Module X: Case Studies - Identifying the core challenge and user needs, developing a user-centered approach to address the problem, applying relevant design thinking tools and methodologies, iterating on solutions through prototyping and user testing.

Case Study 1 - Improving Accessibility in E-commerce Platforms (E-commerce Industry)

Case Study 2 - Enhancing User Engagement in a Learning Management System (Education Technology)

Case Study 3 - Streamlining the Onboarding Process for a Mobile Fitness App (Health & Wellness Technology) (10 hours)

Core Compulsory Readings

1. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation by Tim Brown (First Edition, 2009)
2. The Design Thinking Toolbox: A Guide for Mastering the Art of Innovative

Problem-Solving by Michael Lewrick, Patrick Link, and Leslie Snyder (First Edition, 2018)

3. Sprint: Solving Big Problems and Testing New Ideas in Just Five Days by Jake Knapp (First Edition, 2016)
4. Design Thinking for Dummies by Gavin Ambrose and Paul Dunne (First Edition, 2018)

Core Suggested Readings

1. Creative Confidence: Unleashing the Creative Potential Within Us All by Tom Kelley (First Edition, 2013)
2. This Is Service Design Doing: Applying Service Design Thinking in the Real World by Marc Stickdorn (First Edition, 2018)
3. Design Thinking for Business Growth: How to Design and Scale Business Models and Business Ecosystems by Patrick van der Pijl, Alexander Osterwalder, and Yves Pigneur (First Edition, 2014)

ACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

KU6DSEEVS301 ENVIRONMENTAL ENGINEERING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	DSE	300	KU6DSEEVE301	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description: This course helps the learners to understand about environmental engineering and how it intersects with IT industry. It will also help the learner about green computing practices.

Course Objectives

The Course aims:

- To understand the relation between environmental engineering and IT industry
- To study the green computing practices for attaining sustainability in IT industry
- To know about the E-waste management practices and legislations
-

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Able to identify the intersections of IT in environmental engineering
CO2	Estimate and monitor the carbon footprint from IT industry.
CO3	To organize an appropriate management method for hazardous wastes and E-wastes.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓

COURSE CONTENTS

Module I: Environmental engineering v/s IT industry:

Environmental Engineering: Introduction, Definition, Scope, Role of environmental engineers. Environmental engineering in the context of IT industry: Role of IT in environmental engineering, Intersections of IT in environmental engineering. (10 hours)

Module II: Energy Efficiency & Green Computing:

Energy Efficiency & IT Industry**:** Energy consumption in IT industry, Optimization of energy usage in IT Industry - server virtualization, efficient cooling methods, use of renewable energy sources, implementation of green data centers**.** Green Computing Practices: Optimize software algorithms to reduce computational energy consumption, power management strategies, encouraging responsible printing and paper usage. (20 hours)

Module III: Intersections of IT in Environmental Engineering:

Carbon Footprint in IT Industry**:** Measurement of carbon footprint, Measures to reduce carbon footprint**.** Lifecycle Assessment & IT Industry: Definition, Concepts in LCA, Types of LCA, Lifecycle stages and databases, Lifecycle Impact Assessment & Impact Categories, Environmental Labeling**.** Sustainable IT Procurement**:** Sustainability in IT industry, Selection of equipment and services**.** Environmental Monitoring and Reporting**:** Developing monitoring systems, Tracking environmental performance indicators, Preparation of environmental reports. (25 hours)

Module IV: Solid Waste Management:

Solid Waste Management: Municipal Solid Waste: Types, Sources, Characteristic, Waste Collection and Transport, Techniques/Processing of Solid Waste Recovery, Reclamation, Recycle and Reuse of Resources, Disposal Methods. Industrial and Hazardous Waste Management: Listed Hazardous Waste, Hazardous Waste Rules. Plastic Waste Management: Classification, Reduce, Reuse, Recycle and Recovery, Plastic Waste Management Rules, 2016.E-Waste Management**:** Strategies for responsible disposal, Recycling, and refurbishment of equipment's, Environmental regulations compliance - Restriction of Hazardous Substances (RoHS) directive and the Waste Electrical and Electronic Equipment (WEEE) directive. Methods for effective reduction and recycling of E-waste E-waste management in India - E-waste (Management and Handling) Regulations, 2010, E-waste (Management) Rules, 2016 and E-Waste (Management) Rules, 2022. (25 hours)

Module X

Practical application of Environmental engineering – Casse study- Industry Visit. (10 hours)

Suggested Readings

1. H.S. Peavy, D.R. Rwe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill Book Company, New York.
2. S.P. Misra and S.N. Pandey – Essential Environmental studies – Ane books Pvt. Ltd.
3. Reddy, B. A. K.; Assenza, G.; Assenza, D.; Hasselmann, F. Energy efficiency and climate change: Conserving power for a sustainable future; 2009.
4. Kanoglu, M.; Dr, Y. a. C. Energy efficiency and management for engineers;

McGraw-Hill Education, 2020.
5. Hilty, L. M.; Aebischer, B. ICT innovations for Sustainability; 2015.
6. Kahhat, R.; Hieronymi, K.; Williams, E. E-waste Management: From Waste to Resource; Routledge, 2012.
7. Prasad, M. N. V.; Vithanage, M.; Borthakur, A. Handbook of Electronic Waste Management: International Best Practices and Case Studies; Butterworth-Heinemann, 2019.
8. Klöpffer, W.; Grahl, B. Life Cycle Assessment (LCA): A Guide to Best Practice; John Wiley & Sons, 2014.
9. Notarnicola, B.; Settanni, E.; Tassielli, G. Life Cycle Assessment (LCA). In Wiley eBooks; 2014.
10. Chatterjee, D.; Rao, S. Computational sustainability. ACM Computing Surveys; 2020.
11. Patra, R. K. Green computing and its applications; 2021.
12. Muthu, S. S. The Carbon Footprint Handbook; CRC Press, 2015.

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion**

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes

1. Briefly explain water quality parameters.
2. Discuss on the importance of water quality standards.
3. Explain the role of IT in environmental engineering.
4. Briefly explain the methods for effective reduction and recycling of E-waste
5. Write a note on Carbon Footprint in IT Industry

Semester VII

KU7DSCCSE401 SIGNALS AND SYSTEMS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSC	400	KU7DSCCSE401	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE duration : 2 hours for theory and 3 hours for Lab**

Course Description:

Signals and Systems starts from the basic concepts of discrete-time signals and proceed to learn how to analyze data via the Fourier transform, how to manipulate data via digital filters and how to convert analog signals into digital. Z Transform and its applications also discussed in this course. Design and lab exercises are also significant components of the course

Course Objectives

- To introduce student's basic techniques in designing and implementing digital signal processing systems.
- To learn basic method of pulse code modulation
- To explore the concept of convolution and correlation
- To learn basic methods of spectral analysis.
- To explore concept of CTFT, DTFT, DFT and FFT

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	study the modern digital signal processing algorithms and applications
CO2	study the concept of discrete time signals and systems, and Comprehensive knowledge to use of digital systems.
CO3	study the concept of convolution and correlation
CO4	To study the concepts of CTFT, DTFT, DFT, FFT in detail also Z transform

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Signals and Signal Processing - Characterization and classification of Signals, Typical signal processing operations, Typical Signal Processing Applications, Advantage of Digital Signal Processing (20 Hours)

Module 2: Classification of signals –Introduction to vector space - The concept of frequency in continuous and discrete time signals -Sampling of analog signals – Sampling theorem – Quantization and Coding –Digital to analog conversion (20 Hours)

Module 3: Time Domain Representation of signals and systems - Discrete time signals, Operations on sequences, Discrete time Systems, Linear Time invariant Discrete Time Systems-convolution sum –correlation of discrete time signals , Z-Transform (20 Hours)

Module 4: Frequency Analysis of Signals - Frequency Analysis of Continuous Time Signals, Frequency Analysis of Discrete Time Signals, Fourier Transform of discrete time signals –Discrete Fourier Transform (DFT). FFT(Qualitative idea only)-Wavelet Transform - FIR and IIR Filters (20 Hours)

Module X :

Digital Signal Processing Applications

> Audio signal processing, Image and video processing, Speech processing and recognition, Telecommunications and digital communication systems, Control systems and feedback control.

Advanced Topics in Digital Signal Processing

> Adaptive signal processing, Multidimensional signal processing, Wavelet transforms, Compressed sensing and sparse signal processing, Applications in biomedical signal processing

Multirate Signal Processing

> Decimation and interpolation, Poly phase representation, Filter banks and their applications, Multistage implementation of decimators and interpolators (10 Hours)

Core Compulsory Readings

1. Proakis, John G. and Dimitris G. Manolakis. *Digital signal processing: principles algorithms and applications*. Pearson Education India, 2001.

Core Suggested Readings

2. Roberts, Michael J. *Signals and systems: analysis using transform methods and MATLAB*. McGraw-Hill Higher Education, 2011.

3. Oppenheim, Alan V., and Ronald W. Schafer. Digital Signal Processing [by] Alan V. Oppenheim [and] Ronald W. Schafer.Prentice-Hall, 1975.

4. Antoniou, Andreas. *Digital signal processing*.McGraw-Hill, 2016.

5. Rabiner, Lawrence R., Bernard Gold, and C. K. Yuen. *Theory and application of digital signal processing*. Prentice-Hall, 2007

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes

1. What are the main differences between continuous-time signals and discrete-time signals? Provide examples of each.
2. Explain the concept of frequency in the context of both continuous-time and discrete-time signals. How is it different in these two domains?
3. What is the Nyquist-Shannon sampling theorem, and why is it important in the process of sampling analog signals to convert them into digital signals?

4. Describe the process of quantization and coding in digital signal processing. How does it impact the accuracy of the digitized signal?
5. What are the advantages of using digital signal processing techniques over analog signal processing methods? Provide specific examples of applications where digital signal processing excels.
6. Define the concept of convolution sum in discrete-time systems. How is it related to linear time-invariant (LTI) systems?
7. Explain the Z-transform and its significance in representing and analyzing discrete-time signals and systems.
8. What is the Fourier Transform, and how does it enable frequency analysis of continuous-time signals? Provide an example of its application in signal processing.
9. Discuss the Discrete Fourier Transform (DFT) and its practical importance in analyzing discrete-time signals in the frequency domain.
10. Compare and contrast Finite Impulse Response (FIR) filters and Infinite Impulse Response (IIR) filters in terms of their characteristics, applications, and advantages.

KU7DSCCSE402 QUANTUM GATES AND CIRCUITS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSC	400	KU7DSCCSE402	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE duration : 2 hours for theory and 3 hours for Lab**

Course Description: The course "Quantum Gates and Circuits" provides an in-depth exploration of the foundational concepts and practical applications of quantum computing. Students learn about quantum gates' significance in building quantum circuits and gain practical skills in designing and implementing these circuits for computational tasks. Through theoretical instruction and hands-on exercises, students acquire the knowledge needed to manipulate quantum information effectively, preparing them for further studies and applications in the field of quantum computing.

Course Objectives:

- Provide an overview of quantum computing principles and their integration with machine learning.
- Explore quantum gates, superposition, and entanglement in machine learning contexts.
- Introduce advanced topics including quantum neural networks and clustering algorithms.
- Equip students with skills to implement quantum machine learning for practical applications.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Proficiency in understanding the principles of quantum computing and their application in machine learning tasks.
CO2	Mastery of quantum gates, superposition, and entanglement concepts for machine learning algorithms.
CO3	Competence in implementing and utilizing quantum neural networks and clustering algorithms.
CO4	Ability to apply quantum machine learning techniques to solve real-world problems and challenges effectively.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Overview of Quantum Computing -Basic principles of quantum mechanics-Quantum gates and circuits-Quantum superposition and entanglement-Introduction to Quantum Machine Learning-Classical vs. quantum machine learning -Applications of quantum machine learning -Variational Encoders -Principles of variational encoders -Quantum variational autoencoders -Training variational encoders (20 Hours)

Module 2: Basics of Neural Networks -Overview of classical neural networks -Activation functions and network architectures -2.2 Quantum Neural Networks (QNNs) -Introduction to QNNs -Quantum gates in neural networks -Training QNNs using quantum algorithms - Fundamentals of classical SVM -Quantum Support Vector Machines (QSVM)-Quantum kernel methods -Implementing

QSVM for classification tasks- Convolutional neural networks overview-Quantum convolutional layers- Training and applications of QCNN (20 Hours)

Module 3: Introduction to Clustering -Basics of clustering algorithms -K-means clustering and its limitations-Quantum K-means Clustering - Quantum distance measures -Quantum version of the K-means algorithm (15 Hours)

Module 4: Quantum Reinforcement Learning -Basics of reinforcement learning -Quantum reinforcement learning algorithms -Applications and challenges-Quantum Generative Models-Introduction to generative models- Quantum generative models overview-Applications in data generation and anomaly detection - Quantum Transfer Learning- Transfer learning concepts -Quantum transfer learning algorithms-Case studies and practical implementations (15 Hours)

Module X: Quantum machine learning and its applications in financial modelling, climate prediction- drug discovery- Gibs boson sampling (10 Hours)

Core Compulsory Readings

1. Quantum Machine Learning: What Quantum Computing Means to Data Mining" by Peter Wittek
2. Quantum Machine Learning" by Jacob Biamonte, Peter Wittek, Nicola Pancotti, Patrick Rebentrost, and Nathan Wiebe

Core Suggested Readings

1. Various research papers from reputed journals

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What are the basic principles of quantum mechanics and their relevance to quantum computing?
2. Explain the concepts of quantum gates, superposition, and entanglement, and their significance in quantum machine learning.
3. Compare classical neural networks with quantum neural networks, highlighting their differences and similarities.
4. How are quantum gates utilized in quantum neural networks, and what advantages do they offer over classical counterparts?
5. What are the fundamental concepts of clustering algorithms, and how are they applied in classical machine learning?
6. Discuss the quantum version of the K-means algorithm and its potential advantages in quantum clustering tasks.
7. Explain the basics of reinforcement learning and its applications in quantum machine learning.
8. How do quantum generative models contribute to data generation and anomaly detection in machine learning applications?

KU7DSCCSE403 ARTIFICIAL INTELLIGENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSC	400	KU7DSCCSE403	4	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	0	1	50	50	100	2

Course Description:

The objective of the course is to impart theoretical knowledge in the specialized area of Artificial Intelligence. The program focuses on building a comprehensive understanding on the fundamentals of Artificial Intelligence, ability to solve new problems, and a capacity to learn continually and interact with inter- disciplinary groups. This course has the potential to energies scientific and social advancement through technological innovation and entrepreneurship.

Course Objectives:

CO1: To introduce basic principles that drive complex real-world intelligence applications.

CO2: To introduce and discuss the basic concepts of AI Techniques.

CO3: To understand how the animal (especially human) intelligence is mimicked by the machines using AI algorithms.

COURSE CONTENTS

Module 1: Introduction - Overview of AI applications. Introduction to representation and search. The Propositional calculus, Predicate Calculus, Using Inference Rules to produce Predicate Calculus expressions, Application.

Module 2: Introduction to structure and Strategies for State Space search, Graph theory, Strategies for state space search, using the State Space to Represent Reasoning with the Predicate calculus (Sate space description of a logical system, AND/OR Graph). Heuristic Search: introduction, Hill-Climbing and Dynamic Programming, The Best-first Search Algorithm, Admissibility, Monotonicity and Informedness.

Module 3: Building Control Algorithm for State space search – Introduction, Production Systems, The blackboard architecture for Problem solving. Knowledge Representation – Issues, History of AI representational schemes, Conceptual Graphs, Alternatives to explicit Representation, Agent based and distributed problem solving. Strong Method Problem Solving –Overview of Expert System Technology, Rule Based Expert system, Model - Based, Case-Based and Hybrid Systems (Introduction to Model based reasoning, Introduction to Case Based Reasoning, Hybrid design), Introduction to Planning. Reasoning in Uncertain Situation(introduction), logic based Adductive Inference. Introduction to PROLOG.

Module 4: Machine Learning: Symbol Based – Introduction, Frame –work. The ID3 Decision tree Induction algorithm. Inductive bias and Learnability, Knowledge and Learning, Unsupervised learning, Reinforcement Learning, Machine Learning: Connectionist – Introduction, foundations, Perceptron learning. Machine learning: Social and emergent: Models, The Genetic Algorithm, Artificial Life and Social based Learning.

Core Compulsory Readings

1. S. Russel and p. Norvig, Artificial intelligence – A Modern Approach, 3rdEdn, Pearson

2. D W Patterson, introduction to Artificial Intelligence and Expert Systems,

PHI, 1990

Core Suggested Readings

1. George F Luger, Artificial Intelligence – Structures and Strategies for Complex problem solving, 5thEdn, Pearson
2. George J Klir and Bo yuan, Fuzzy sets and fuzzy logic: Theory and Applications, Prentice Hall India 1995

3. E. Rich, K. Knight, S B Nair, Artificial intelligence, 3rdEdn, McGraw Hill

TEACHING LEARNING STRATEGIES

- Lecturing, Team Learning, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Print

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 4 Credit Theory

Sample Questions to test Outcomes.

1. When you think of AI, what sort of challenges come to your mind?
2. Criticize Turing's criteria for computer software being "intelligent".
3. What are the major issues in *knowledge representation*?
4. Assume that you are developing an expert system for troubleshooting a complex electronic system. What is the source of uncertainty that can arise in this application?
5. Explain in detail about reinforcement learning with example.
6. In A* Algorithm, what do you mean by Estimated cost, h(n)?

KU7DSCCSE404 DATA SCIENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSC	400	KU7DSCCSE404	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The data science course provides a comprehensive overview of the interdisciplinary field, covering fundamental concepts such as data acquisition, preprocessing, statistical analysis, and visualization, as well as advanced techniques like big data processing and deep learning. Students gain hands-on experience with programming languages like Python and R, exploring real-world applications across various domains. Emphasis is placed on ethical considerations and responsible AI practices. By course end, students are equipped to tackle complex data challenges and drive innovation in data-driven industries.

Course Objectives:

- To demonstrate proficiency with statistical analysis of data.
- To develop the ability to build and assess data-based models.
- To execute statistical analyses and interpret outcomes.
- To apply data science concepts and methods to solve problems in real-world contexts and will communicate these solutions effectively.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Demonstrate proficiency with statistical analysis of data.
CO2	Develop the ability to build and assess data-based models.
CO3	Execute statistical analyses and interpret outcomes.
CO4	Apply data science concepts and methods to solve problems in real-world contexts and will communicate these solutions effectively.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction: Introduction data acquisition, data preprocessing techniques including data cleaning, selection, integration, transformation and reduction, data mining, interpretation. (10 hours)

Module 2: Statistical data modeling: Review of basic probability theory and distributions, correlation coefficient, linear regression, statistical inference, exploratory data analysis and visualization. (15 hours)

Module 3: Predictive modeling: Introduction to predictive modeling , decision tree, nearest neighbor classifier and naïve Baye's classifier, classification performance evaluation and model selection. (25 hours)

Module 4: Descriptive Modeling: Introduction to clustering, partitional, hierarchical, and density-based clustering (k-means, agglomerative, and DBSCAN), outlier detection, clustering performance evaluation. Association Rule Mining: Introduction to frequent pattern mining and association rule mining, Apriori algorithm, measures for evaluating the association patterns. Text Mining: Introduction of the vector space model for document representation, term frequency-inverse document frequency (tf-idf) approach for term weighting, proximity measures for document comparison, document clustering and text classification. (30 hours)

Module X: Deep Learning, Ensemble Learning, Time Series Analysis, Anomaly Detection, Reinforcement Learning, (15 hours)

Core Compulsory Readings

1. W. McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy and iPython, 2nd Ed., O'Reilly, 2017.

Core Suggested Readings

1. P. Tan, M. Steinbach, AKarpatne, and V. Kumar, Introduction to Data Mining, 2nd Ed., Pearson Education, 2018.
2. G James, D Witten, T Hastie and R Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer Texts in Statistics, Springer, 2013.
3. G. Grolemund, H. Wickham, R for Data Science, 1st Ed., O'Reilly, 2017.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes

1. What are the main steps involved in data preprocessing, and why is it crucial in the data analysis process?

2. Explain the difference between data cleaning, integration, transformation, and reduction, providing examples of each.

3. How does exploratory data analysis help in understanding the underlying patterns and relationships within a dataset? Provide examples of visualization techniques used in exploratory data analysis.

4. Discuss the role of linear regression in statistical data modeling, including its assumptions, interpretation of coefficients, and applications in real-world scenarios.

5. Compare and contrast decision tree, nearest neighbor classifier, and naïve Bayes classifier in terms of their underlying principles, advantages, and limitations.

6. Explain the process of model selection and performance evaluation in predictive modeling. What are some common metrics used to evaluate classification models?

7. Describe the main types of clustering algorithms (partitional, hierarchical, and density-based) and discuss their respective strengths and weaknesses.

8. How does the Apriori algorithm work in frequent pattern mining, and what are the key measures used to evaluate association patterns? Provide examples of real-world applications of association rule mining.

S7 - List of Discipline Specific Electives (DSE) (POOL F)

KU7DSECSE405 HIGH-PERFORMANCE COMPUTING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSE	400	KU7DSECSE405	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course on High-Performance Computing (HPC) provides a comprehensive understanding of the principles, architectures, and techniques involved in executing computationally intensive tasks. Students will learn about parallel computing, distributed systems, and the utilization of HPC clusters for scientific simulations and data analysis. The course covers topics such as programming models, optimization strategies, and performance evaluation to maximize the efficiency of HPC applications.

Course Objectives:

- Understand the principles and foundations of high-performance computing and its importance in scientific and computational-driven fields.
- Gain knowledge of parallel computing architectures and techniques used in high-performance computing.
- Develop skills in programming and optimizing algorithms for efficient execution on HPC clusters.
- Learn to utilize advanced tools and frameworks for managing and analyzing large-scale data in high-performance computing environments.
- Apply the acquired knowledge and skills to solve complex computational problems and conduct scientific simulations using high-performance computing resources.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	The learner will be able to design, formulate, solve and implement high performance versions of standard single threaded algorithms
CO2	The learner will know and will be able to demonstrate the architectural features in the GPU and MIC hardware accelerators.
CO3	The learner will be able to design programs to extract maximum performance in a multicore, shared memory execution environment processor.
CO4	The learner will be able to design and deploy large scale parallel programs on tightly coupled parallel systems using the message passing paradigm.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Levels of parallelism (instruction, transaction, task, thread, memory, function)- Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc)- Architectures: N-wide superscalar architectures, multi-core, multi-threaded. (15 hours)

Module 2: Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee

Microarchitecture and Intel Nehalem microarchitecture- Memory hierarchy and transaction specific memory design- Thread Organization. (15 hours)

Module 3: Synchronization- Scheduling- Job Allocation-Job Partitioning-Dependency Analysis- Mapping Parallel Algorithms onto Parallel Architectures-Performance Analysis of Parallel Algorithms. (15 hours)

Module 4: Bandwidth Limitations- Latency Limitations- Latency Hiding/Tolerating Techniques and their limitations- Power-aware Processing Techniques-Power-aware Memory Design- Power-aware Interconnect Design-Software Power Management. Petascale Computing-Optics in Parallel Computing- Quantum Computers- Recent developments in Nanotechnology and its impact on HPC. (15 hours)

Module X :

Exascale Computing, Heterogeneous Computing, Parallel I/O and Storage Systems, Distributed Shared Memory (DSM), Extreme-Scale Data Analytics, Deep Learning and HPC, High-Performance Computing in Edge and IoT, (15 hours)

Core Compulsory Readings

1. George S. Almasi and AlanGottlieb, Highly Parallel Computing, Benjamin Cumming Publishers.
2. Kai Hwang ,Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw Hill 1993

Core Suggested Readings

1. David Culler, Jaswinder Pal Singh, Anoop Gupta, Parallel Computer Architecture: A hardware/Software Approach, Morgan Kaufmann, 1999.

2. K. Hwang& Z. Xu, Scalable Parallel Computing – Technology, Architecture, Programming., McGraw Hill 1998.
3. William James Dally and BrianTowles, Principles and Practices on Interconnection Networks, Morgan Kauffman 2004.
4. Hubert Nguyen , GPU Gems 3, Addison Wesley, 2008, (Chapter 29 to Chapter 41)
5. AnanthGrama, Anshul Gupta, George Karypis, and Vipin Kumar, Introduction to Parallel Computing, , 2nd edition, Pearson, 2003.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. What is high-performance computing (HPC) and how does it differ from traditional computing?
2. What are the main characteristics and advantages of parallel computing in the context of HPC?
3. What are some common architectures used in HPC systems, and how do they contribute to improved performance?
4. How can HPC clusters be utilized for scientific simulations and data analysis?
5. What programming models and languages are commonly used in HPC applications?

6. How can algorithms be optimized for efficient execution on HPC systems?
7. What are the key performance evaluation metrics used to assess the efficiency of HPC applications?
8. What are some tools and frameworks available for managing and analyzing large-scale data in HPC environments?
9. How does HPC contribute to advancements in fields such as weather forecasting, computational biology, and artificial intelligence?
10. What are the current challenges and future trends in high-performance computing?

KU7DSECSE406 COMPUTER VISION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSE	400	KU7DSECSE406	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course focuses on building a broad understanding on the fundamentals of computer vision. The objective of the course is to communicate theoretical knowledge about machine vision. This is a field of artificial intelligence that enables computers and systems to derive meaningful information from visual inputs and has the prospective to energies scientific advancement through technological revolution

Course Objectives:

- To understand the basic concepts of computer vision and techniques involved
- Introduce applications of machine vision
- Illustrate knowledge about motion analysis

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the basic fundamentals of computer vision
CO2	Describe various aspects of object recognition
CO3	Illustrate various aspects of 3D vision
CO4	Analyze motion application techniques

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction: Motivation, Difficulty, Image analysis tasks, Image representations, Image digitization, Image properties, Colour images, Cameras. Data Structures: Levels of image data representation - Traditional image data structures - Hierarchical data structures. (15 hours)

Module 2: Object Recognition: Knowledge representation, Statistical pattern recognition, Neural nets, Syntactic pattern recognition, Recognition as graph matching, Optimization techniques in recognition, Fuzzy systems (15 hours)

Module 3: 3D vision: 3D vision: Tasks - Basics of projective geometry - Scene construction from multiple views, Uses: Shape from X - Full 3D objects - 3D model based vision (15 hours)

Module 4: Motion Analysis: Differential motion analysis methods, Optical flow, Analysis based on interest points, Detection of specific motion patterns, , Motion models to aid tracking.(15 hours)

Module X :

Texture: Statistical texture description, Syntactic texture description methods, Hybrid texture description methods, Texture recognition method applications ,2D view based 3D representation,Video Tracking (15 hours)

Core Compulsory Readings

1. Szeliski, Richard, Computer Vision: Algorithms and Applications- 2ndEdn, Springer Verlag, 2022.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Cengage Learning, New Delhi, 2014.
3. Wesley E. Synder and Hairong Qi, Machine Vision, Cambridge University Press, USA, 2010.

Core Suggested Readings

1. Rafael C Gonzalez, Richard E Woods, Steven L Eddins, Digital Image Processing, Pearson Education, New Delhi, 2009.
2. Shapiro L and Stockman G, Computer Vision, Prentice-Hall, 2001

TEACHING LEARNING STRATEGIES

- Lecturing, Seminar, Digital Learning, Audio, Video

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. How do humans recognize objects and how can we replicate this process in machines?

2. What are some applications of projective geometry in 3D vision, and how do they impact industries such as robotics, autonomous vehicles, and augmented reality?

3. What are some challenges faced when working with 2D view based 3D representations?

4. How can motion models be adapted to different tracking scenarios, such as in crowded environments, fast-moving objects, or occluded scenes?

5. What are the different types of video tracking algorithms, and how do they differ in terms of accuracy, speed, and robustness?

6. How can machine learning be used to improve the accuracy and efficiency of motion pattern detection in computer vision? Discuss the advantages and limitations of deep learning, supervised learning, and unsupervised learning methods in this context.

7. What are the main applications of motion pattern detection in computer vision, and how can they be applied in real-world scenarios? Discuss the challenges associated with deploying these methods in real-world applications.

8. What are the potential future directions of motion models in tracking, such as in 3D tracking or dynamic scene analysis? Discuss the need for novel algorithms and hardware advancements to realize these directions.

9. What is the role of camera calibration in multi-view stereo reconstruction, and how can it be performed accurately?

10. How can optical flow be used for motion analysis and object tracking, and what are the main challenges in these tasks?

KU7DSECSE407 INFORMATION SECURITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSE	400	KU7DSECSE407	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course provides with the basics concepts of cryptography including traditional ciphers, block ciphers, stream ciphers, private and public key cryptosystems. The course also includes key-exchange algorithms, hash functions, authentication systems like MAC and digital signature as well as network security protocols.

Course Objectives:

Accomplish knowledge on basic concepts of information security

- Study different cryptographic techniques
- Obtain knowledge on Message Authentication and Digital Signatures
- Accomplish knowledge about Hash functions
- Learn various network security protocols

Course outcomes

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the basic concepts of information security
CO2	Illustrate different cryptographic techniques
CO3	Describe various concepts of Message Authentication
CO4	Explain Hash Functions and Basic network security Essentials

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Foundations of Cryptography and security: Ciphers and secret messages, security attacks and services.Classical Encryption techniques - Symmetric cipher model, substitution techniques, transposition techniques, steganography. Basic Concepts in Number Theory and Finite Fields (15 hours)

Module 2: Block cipher principles – The data encryption standard (DES) – strength of DES – Differential and linear cryptanalysis – Block cipher design principles. Advanced encryption standard – AES structure – AES transformation function – key expansion – implementation. Block cipher operations –Multiple encryption – ECB – CBC – CFM – OFM – Counter mode. Pseudo Random Number generators - design of stream cipher, RC4. (15 hours)

Module 3: Public Key cryptography: Prime numbers and testing for primality, factoring large numbers, discrete logarithms. Principles of public-key crypto systems – RSA algorithm. Diffi-Helman Key exchange, Elgammal Cryptographic systems - Hash functions – examples – application – requirements and security – Hash function based on Cipher block chaining – Secure Hash algorithm (15 hours)

Module 4: Message authentication requirements - Message authentication functions – requirements of message authentication codes - MAC security – HMAC – DAA – CCM – GCM. Digital signatures, Digital signature standard. Transport-Level Security ,Wireless Network Security, Electronic Mail Security, IP Security (15 hours)

Module X (Teacher Specific):

Introduction on Security Essentials Malicious Software ,Types of Malicious Software; Intruders , Intrusion Detection;Firewalls ,The Need for Firewalls, Firewall Characteristics , Types of Firewalls; Legal and Ethical Issues, Cybercrime and Computer Crime ;Intellectual Property .(15 hours)

Core Compulsory Readings

1. William Stallings, Cryptography and Network Security, Pearson 2004

Core Suggested Readings

1. Foorouzan and Mukhopadhyay, Cryptography and Network security, 2ndedn
2. BuceSchneier., Applied cryptography – protocols and algorithms, SpringerVerlag 2003

3. William Stallings, Network Security Essentials, , 4thedn, Pearson
4. Pfleeger and Pfleeger, Security in Computing, 4thEdn, Pearson

TEACHING LEARNING STRATEGIES

- Lecturing, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1.Define Ciphers and List various types of security attacks

2.Explain any four Classical Encryption techniques

3.Define various Principles of public-key crypto systems

4. Explain RSA algorithm

5.Describe Hash function based on Cipher block chaining

6.Write the principle of Pseudo Random Number generators

7.List requirements of message authentication codes

8.Explain MAC security – HMAC operations

9.List Different Types of Malicious Software

10.Explain with necessary diagrams an intrusion detection system

KU7DSECSE408 DATA AND INFORMATION VISUALIZATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSE	400	KU7DSECSE408	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course focuses on building creative and technical skills to transform data into visual reports for the purpose of a better understanding. Students will learn to organize and visualize data with an emphasis on applying design principles to produce clear, elegant graphs from the data.

Course Objectives:

- Employ best practices in data visualization to develop charts, maps, tables, and other visual representations of data
- Implement visualizations in Python

Course Outcomes:

SL #	Course Outcomes
CO1:	Identify appropriate visualization methods for a given data type
CO2:	Describe information visualization methods such a cladogram, cartogram, heatmap and dendrogram
CO3:	Illustrate various methods for information visualization
CO4:	Explain various aspects of scientific visualization

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Data and types of data, Data variability, uncertainty and context. Basics of Data Visualization: Definition of Data Visualization, Need for Visualization, how to visualize data, General types of Data Visualization, pros and Cons of Data Visualization. Visualization Components: Visual cues, Coordinate systems, Scales, and Context. Diagrams used for data visualization: Bar chart, Histogram, Scatter plot, Scatter plot, Network, Streamgraph, Tree map, Gantt chart, Stripe graphic, Animated spiral graphic. Visualization based on types of data: Visualizing Categorical data, Visualizing Time series data, Visualizing Spatial data (15 Hours)

Module 2: Information Visualization: Definition, Objectives of Information Visualization. Visual representation of large-scale collection of non - numerical information. Design Principles of Information Visualization: Principle of Simplicity, Principle of Proximity, Principle of Similarity, Principle of Closure, Principle of Connectedness, Principle of Good Continuation, Principle of Common fate, Principle of Familiarity, Principle of Symmetry (15 Hours)

Module 3: Methods for Information Visualization: Cartogram, Cladogram (phylogeny), Concept Mapping, Dendrogram (classification). Graph drawing, Heat map, Hyperbolic Tree, Tree mapping Multidimensional scaling. Information visualization reference model (15 Hours)

Module 4: Scientific visualization: Introduction, Methods for visualizing two-dimensional and three-dimensional data sets, volume visualization. Data Visualization using in Python matplotlib Module, pyplot, plot(), scatter, bar charts, Formatting, figure(), subplot(), text(), xlabel(), ylabel(), title(), Plotting Mathematical Functions (20 Hours)

Module X :

Case study with real world problems, techniques for creating interactive visualizations using tools like D3.js, Plotly, or Bokeh. Geospatial Visualization, Network Visualization, Text and Document Visualization, Temporal Visualization, Biomedical Visualization (10 Hours)

Core Compulsory Readings

1. Nathan Yau, Data Points. Wiley Big Data Series
2. Healy, Kieran, Data Visualization: A Practical Introduction. Princeton University Press
3. Ben Bederson and Ben Shneiderman. The Craft of Information Visualization: Readings and Reflections. Morgan Kaufmann, 2003

4. Riccardo Mazza. Introduction to Information Visualization, Springer, 2009
5. Gowri shankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/Taylor & Francis, 2018. ISBN-13: 978-0815394372

Core Suggested Readings

1. Alberto Fernandez Villan, Mastering OpenCV 4 with Python, Packt Publishing Ltd
2. Dr. R Nageswara Rao, Core Python Programming, 2nd edition, Dreamtech Publisher, 2019
3. Geron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 1st Edition,O'Reilly Media, 2017.
4. Wesley J. Chun, Core Python Programming, Second Edition, Publisher: Prent Hall Pub
5. Introduction to Computer Science using Python - Charles Dierbach, Wiley,2015

TEACHING LEARNING STRATEGIES

- Lecturing, Team Learning, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Print

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. Design a graph and describe the elements of data visualization with the help of it.
2. How do you explain positive and negative correlation in scatter plots.
3. Summarize design principles behind information visualization.
4. Design a cladogram and mark its parts.
5. Show the conversion from tree diagram to treemap with the help of an example diagram
6. Explain different scientific visualization techniques.
7. Discuss Any one surface rendering method.
8. Write a python program to plot y=x and $y=x^2$ as subplots.

KU7DSECSE409 CRYPTOGRAPHY AND NETWORK SECURITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	DSE	400	KU7DSECSE409	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course introduces the basics of cryptography and network security. Fundamental concepts of cryptography the fundamental concepts of main concepts of networking to the learner. TCP/IP network model is taken as the basis for the discussion. The course provides the learner a brisk walk through the fundamentals concepts of symmetric and public key cryptography are outlined in the course. The course also deals with the basic topics on network security.

Course Objectives:

- Provide basic knowledge on the concepts of cryptography and network security
- Provide fundamentals concepts of symmetric and public key cryptography
- Familiarize with the basic concepts of network security

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Identify security concepts, challenges and attacks in computer security
CO2	Illustrate principles and algorithms in various cryptography models
CO3	Explain the fundamental concepts of cloud security
CO4	Describe the basics of transport layer security and wireless network security

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Security Concepts: - CIA Triad - Challenges. OSI Security Architecture: Attacks - Services - Mechanisms - Basic Design Principles of Security Design - A Network Security Model - Standards. Cryptography: Symmetric Cipher Model - Substitution Techniques: Caesar - Monoalphabetic - Playfair. Transposition Techniques - Steganography. (15 hours)

Module 2: Traditional Block Cipher Structure - Feistal Cipher Structure - DES - Triple DES - AES. Principles of Public key Crypto Systems – RSA Algorithm - Diffie Hellman Key Exchange - Elliptic Curve Arithmetic - Elliptic Curve Cryptography. Hash Functions: Applications - Two Simple Hash Functions.(15 hours)

Module 3: Network Access Control - EAP - IEEE 802.1X Port-Based Network Access Control - Security Risks and Countermeasures in Cloud - Data Protection in Cloud. Transport Level Security: Web Security Considerations - TLS - HTTPS - SSH.(15 hours)

Module 4: Wireless Network Security: Risks - Threats - Measures. Mobile Device Security - IEEE 802.11 - 802.11i. (15 hours)

Module X : Block Cipher Operation - Email Security - IP Security (15 hours)

Core Compulsory Readings

1. C. Siva Ram Murthy & B. S. Manoj: Ad-hoc Wireless Networks, 2nd Edition, Pearson Education, 2011

Core Suggested Readings

1. Ozan K. Tonguz and Gianguigi Ferrari: Ad-hoc Wireless Networks, John Wiley, 2007.
2. Xiuzhen Cheng, Xiao Hung, Ding-Zhu Du: Ad-hoc Wireless Networking, Kluwer Academic Publishers, 2004.
3. C.K. Toh: Ad-hoc Mobile Wireless Networks- Protocols and Systems, Pearson Education, 2002

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Demonstration, Discussion, Questioning and Answering

ASSESSMENT RUBRICS (For Courses with 3L + 1P)

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Semester VIII

KU8DSCCSE501 GENERATIVE AI

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSC	500	KU8DSCCSE501	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This syllabus serves as a comprehensive guide for understanding and exploring the principles, techniques, and applications of Generative AI. The syllabus is designed to provide the necessary foundation and resources to explore the fascinating realm of generative models. By studying the concepts and techniques outlined in this syllabus, the student will gain the knowledge and skills to harness the power of generative models and contribute to the advancement of AI research and applications.

Course Objectives:

- Discuss about the bases of generative artificial intelligence

- Application programming interfaces for generative AI.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Knowledge about theoretical and conceptual bases of generative AI
CO2	Knowledge about the application space for generative AI
CO3	Knowledge about how generative AI should be able to support creativity
CO4	Ability to use generative AI to create content as texts, images, number, music and video.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Generative AI: Definition and scope of Generative AI. Overview of generative models and their applications, Importance of

Generative AI in various domains, Brief discussion on ethical considerations and challenges.(15 hours)

Module 2: Language Models and LLM Architectures: Introduction to language models and their role in AI, Traditional approaches to language modeling, Deep learning-based language models and their advantages, Overview of popular LLM architectures: RNNs, LSTMs, and Transformers, Taxonomy of Transformers. (15 hours)

Module 3: Generative Pre-trained Transformer: Introduction to Generative Pre-trained Transformer and its significance, Pre-training and fine-tuning processes in GPT, Architecture and working of GPT models, Overview of GPT variants and their use cases. (15 hours)

Module 4: Practical Application of Generative Pre-trained Transformer: Introduction to ChatGPT and its purpose, Training data and techniques for ChatGPT, Handling user queries and generating responses,Tips for improving ChatGPT's performance. (15 hours)

Module X :

Simplifying Development with Language Models: Introduction to LangChain and its objectives, Overview of the LangChain framework and its components Streamlining application development using LangChain Examples of applications built with LangChain. Prompt Engineering: Enhancing Model Outputs: Understanding the concept and significance of prompt engineering, Strategies for designing effective prompts, Techniques for controlling model behavior and output quality. Best practices for prompt engineering in generative AI. (15 hours)

Core Compulsory Readings

1. Luger, George F., and William A. Stubblefield. Artificial Intelligence: Structures and Strategies for Complex Problem Solving. Pearson, 2004.

2. Cox, Michael T. Theoretical Models of Reasoning under Uncertainty. Kluwer Academic Publishers, 1988.
3. Vaswani Ashish et al, Attention is all you need. Proc. of NeurIPS (2017), pp.5998-6008.
4. A. Creswell, M. Shanahan, and I. Higgins. Selection-inference: Exploiting large language models for interpretable logical reasoning. arXiv preprint arXiv:2205.09712, 2022.
5. M. Castelli and L. Manzoni, "Generative models in artificial intellige nce and their applications," vol. 12, ed: MDPI, 2022, p. 4127.
6. Radford, A., Narasimhan, K., Salimans, T., & Sutskever, I. (2018). Improving language understanding by generative pre-training. Retrieved from https://www.cs.ubc.ca/~amuham01/LING530/papers/radford2018improving.pdf
7. S. R. Bowman, G. Angeli, C. Potts, and C. D. Manning. A large annotated corpus for learning natural language inference. EMNLP, 2015.
8. R. T. Hughes, L. Zhu, and T. Bednarz, "Generative adversarial networks–enabled human–artificial intelligence collaborative applications for creative and design industries: A systematic review of current approaches and trends," Frontiers in artificial intelligence, vol. 4, p. 604234, 2021.
9. G. Harshvardhan, M. K. Gourisaria, M. Pandey, and S. S. Rautaray, "A comprehensive survey and analysis of generative models in machine learning," Computer Science Review, vol. 38, p. 100285, 2020.
10. S Minaee, T Mikolov, N Nikzad, M Chenaghlu, Large language models: A survey, https://arxiv.org/pdf/2402.06196
11. Khurana, D., Koli, A., Khatter, K. & Singh, S. Natural language processing: state of the art, current trends and challenges. Multimed. Tools Appl. 82, 3713–3744 (2023).

Core Suggested Readings

1. 1. G Adomavicius, A Tuzhilin, Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions, IEEE transactions on knowledge and data engineering, 2005.
2. Babak Amiri, Nikan Shahverdi, Amirali Haddadi, Yalda Ghahremani, "Beyond the Trends: Evolution and Future Directions in Music Recommender Systems Research", *IEEE Access*, vol.12, pp.51500-51522, 2024.
3. Ronakkumar Patel, Priyank Thakkar, Vijay Ukani, "CNNRec: Convolutional Neural Network based recommender systems - A survey", Engineering Applications of Artificial Intelligence, vol.133, pp.108062, 2024.
4. MacNeil, S., Tran, A., Mogil, D., Bernstein, S., Ross, E., & Huang, Z. (2022). Generating
5. diverse code explanations using the GPT-3 large language model. Proceedings of the ACM Conference on International Computing Education Research, 2, 37-39.
6. Manning, C., & Schutze, H. (1999). Foundations of statistical natural language processing. MIT Press.
7. Niu, Z., Zhong, G., & Yu, H. (2021). A review on the attention mechanism of deep learning. Neurocomputing, 452, 48-62.
8. OpenAI. (2022). OpenAI about page. Retrieved from https://openai.com/about/
9. Pavlik, J. V. (2023). Collaborating with ChatGPT: Considering the implications of generative artificial intelligence for journalism and media education. Journalism and Mass Communication Educator. https://doi.org/10.1177/10776958221149577
10. Radford, A., Narasimhan, K., Salimans, T., & Sutskever, I. (2018). Improving language
11. understanding by generative pre-training. Retrieved from
12. https://www.cs.ubc.ca/~amuham01/LING530/papers/radford2018improving.pdf

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. Write a paragraph on Generative Pre-trained Transformer and its significance
2. What do you mean by pre-training process in Generative Pre-trained Transformer?
3. What is fine-tuning process in Generative Pre-trained Transformer?
4. Explain the working of Generative Pre-trained Transformer models during generation.
5. Write a paragraph on the use cases of Generative Pre-trained Transformer variants in text generation.

S8 - List of Discipline Specific Electives (DSE) (POOL G)

KU8DSECSE410 Nature Inspired Computing

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE410	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

Nature-Inspired Computing is an interdisciplinary field that harnesses the principles and processes found in natural systems to develop computational algorithms and techniques. This course introduces students to various nature-inspired computing paradigms, such as evolutionary algorithms, swarm intelligence, immune system algorithms and cellular automata. This course also familiarizes the idea of DNA computing.

Course Objectives:

- To introduce students to the fundamental concepts and principles of nature-inspired computing.
- To explore different nature-inspired algorithms and their applications in solving complex computational problems.

- To provide hands-on experience with implementing and optimizing nature-inspired algorithms.
- To foster critical thinking and problem-solving skills through practical exercises

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Familiarizing Natural Inspirations in problem-solving.
CO2	Explore the concepts of Ant colony optimization and swarm intelligence for solving computationally complex problems.
CO3	Explore the concepts of evolutionary computing, cellular automata.
CO4	Understand fundamental concepts of DNA computing.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Automata Theory: Deterministic finite automata (DFA), Nondeterministic finite automata (NFA), Regular expressions, Equivalence of DFA, NFA, and regular expressions (15 Hours).

Module 2: Context-Free Languages and Grammars: Context-free grammars (CFG), Pushdown automata (PDA), Relationship between CFG and PDA, Parsing techniques (15 Hours)

Module 3: Turing Machines: Definition and examples, Variants of Turing machines, Universal Turing machines, Turing machine equivalents of other models of computation (20 Hours)

Module 4: Computability Theory: Church-Turing thesis, Halting problem and undecidability, recursively enumerable languages, Post correspondence problem (15 Hours)

Module X: Complexity Theory: Time and space complexity, Polynomial-time algorithms and NP-completeness, Cook-Levin theorem, P versus NP problem (10 Hours)

Core Compulsory Readings

1. Stephen Olariu and Albert Y.Zomaya, "Handbook of Bio-Inspired and Algorithms and Applications", Chapman and Hall, 2006.
2. Marco Dorrigo, Thomas Stutzle," Ant Colony Optimization", PHI,2004
3. Eric Bonabeau, Marco Dorrigo, Guy Theraulaz, "Swarm Intelligence: From Natural to Artificial Systems", Oxford University Press,2000
4. Mitchell, Melanie, "Introduction to Genetic Algorithms", ISBN: 0262133164, MIT Press,1996 5. Leandro Nunes de Castro, " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2006

Core Suggested Readings

1. "Introduction to Evolutionary Computing" by A.E. Eiben and J.E. Smith
2. "Swarm Intelligence" by James Kennedy and Russell C. Eberhart
3. "Artificial Immune Systems: A New Computational Intelligence Approach" by Andy Dong and Xiaodong Li
4. "Hands-on genetic algorithms with Python: Applying genetic algorithms to solve real-world deep learning and artificial intelligence problems" by Wirsansky, E.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS (For Courses with 3L + 1P)

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. What is nature-inspired computing, and what are its main principles?
2. Can you explain the concept of evolutionary algorithms and how they mimic biological evolution?
3. How do genetic algorithms work, and what are their main components?
4. Can you describe how particle swarm optimization (PSO) is inspired by the behaviour of swarms or flocks in nature?
5. What are some applications of evolutionary algorithms and PSO in optimization problems?
6. How does ant colony optimization (ACO) simulate the behaviour of ant colonies to solve optimization problems?

KU8DSECSE411 ROBOTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE411	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course deals with fundamental concepts related to designing, and programming robots and the applications of robotics.

Course Objectives:

- To introduce Robotics and Automation including robot classification, design and selection, analysis, and applications in industry.
- To provide the details of operations for a variety of sensory devices that are used on robot.
- To impart knowledge to design automatic manufacturing cells with robotic control using the principle behind robotic drive system, end effectors, sensor, machine vision robot kinematics and programming.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Acquire knowledge about the fundamentals of robotics, classification of robots, and the applications.
CO2	Get a basic understanding of robot kinematics and dynamics.
CO3	Gain comprehensive knowledge of various sensory devices utilized in robotics, including their operational principles, and functionality.
CO4	Develop a thorough understanding of manipulators and different types of end effectors based on their functionalities and applications.
CO5	Acquire knowledge and skills related to path planning and different robot languages used for programming robots.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: INTRODUCTION Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots ROBOT KINEMATICS AND DYNAMICS Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations - Transformation Arithmetic - D-H Representation - Forward and inverse Kinematics of Six Degree of Freedom Robot Arm – Robot Arm dynamics (15 hours)

Module 2: ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS Robot drive mechanisms, hydraulic – electric – servomotor- stepper motor - pneumatic drives, Mechanical transmission method - Gear transmission, Belt drives, cables, Roller chains, Link - Rod systems - Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws (15 hours)

Module 3: MANIPULATORS: Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and Pneumatic manipulators ROBOT END EFFECTORS Classification of End effectors – Tools as end effectors. Drive system for grippers-Mechanical adhesive-vacuum-magnetic-grippers. Hooks & scoops. Gripper force analysis and gripper design. Active and passive grippers.(15 hours)

Module 4: PATH PLANNING & PROGRAMMING: Trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion-Robot languages - computer control and Robot software. (15 hours)

Module X :

Action (Legged locomotion and balance -Arm movement -Gaze and auditory orientation control- Facial expression- Hands and manipulation -Sound and speech generation) Perception (Motion capture/Learning from demonstration -Human activity recognition using vision, touch, sound) Thinking. Models of emotion and motivation. (15 hours)

Core Compulsory Readings

1. Deb S. R. and Deb S., “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2010.
2. John J.Craig , “Introduction to Robotics”, Pearson, 2009.
3. Mikell P. Grooveret. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.

Core Suggested Readings

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill, 1987

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Laboratory sessions, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. What is meant by robot anatomy?
2. Differentiate between kinematics and dynamics.
3. What is the forward kinematics problem for a robotic arm?
4. Describe the characteristics and applications of hydraulic, electric, pneumatic, and stepper motor drives in robotics.
5. Explain the importance of gripper force analysis in robotic applications.
6. What is the importance of trajectory planning in robotics?

KU8DSECSE412 TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE412	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

Time Series Analysis and Forecasting is a practical course that teaches students the essential concepts and techniques for analysing and predicting patterns in time-dependent data. Students will learn how to pre-process and visualize time series data, identify trends and seasonality, and select appropriate models for analysis. The course emphasizes hands-on experience with popular statistical software packages and real-world case studies to reinforce learning. By the end of the course, students will be equipped with the skills to effectively analyse time series data and make accurate forecasts, enabling them to make informed decisions in diverse fields such as finance, economics, and marketing.

Course Objectives:

- Understand the fundamental concepts and characteristics of time series data, including autocorrelation, stationarity, trends, and seasonality.
- Learn various techniques for preprocessing and visualizing time series data to uncover patterns and insights.
- Develop proficiency in selecting and implementing appropriate time series models, such as ARIMA, exponential smoothing, and state space models.
- Gain hands-on experience in forecasting by applying different techniques and evaluating the performance of forecasting models.
- Apply time series analysis and forecasting skills to real-world case studies and projects, enabling students to make data-driven decisions and predictions in practical scenarios.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Perform Data Pre-processing Techniques
CO2	Derive the properties of ARIMA and state-space models
CO3	Choose an appropriate ARIMA model for a given set of data and fit the model using an appropriate package
CO4	Compute forecasts for a variety of linear methods and models

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to time series data, characteristics of time series data, Understanding the components of a time series: trend, seasonality, cyclicality, and residual, Stationary and non-stationary Time Series, Vector Valued and Multidimensional Series (15 Hours)

Module 2: Introduction to Data Acquisition and Pre-processing, Data Cleaning – outlier detection and treatment, handling missing data, Smoothing, Detrending, Data Normalization, Data Transformation, Data Integration, Feature Selection, Handling imbalanced data (20 Hours)

Module 3: Exploratory data analysis, Explore patterns and trends in time series data, Seasonality analysis and detection methods, Autocorrelation and partial autocorrelation analysis. Trend analysis and trend removal techniques, Seasonal decomposition and visualization of components. Classical Regression in the Time Series Context (15 Hours)

Module 4: Introduction to ARMA models, Model identification: selecting appropriate orders of ARIMA models, Parameter estimation and model fitting, Model diagnostics and evaluation: residual analysis, Introduction to SARIMA model. Time series forecasting using ARIMA and SARIMA models (15 Hours)

Module X: Machine Learning Approaches for Time Series Forecasting, Anomaly Detection in Time Series Data, Multivariate Time Series Analysis, Multivariate Time Series Analysis, Deep Learning for Sequence Generation, Time Series Clustering and Classification, Spatial-Temporal Modeling (10 Hours)

Core Compulsory Readings

1. Rob J Hyndman (2014), Forecasting: Principle & Practice, University of Western Australia
2. R. H. Shumway and D. S. Sto_er (2017), Time Series Analysis and Its Applications (With R Examples, fourth Edition).Springer, New York.

Core Suggested Readings

1. Ruey S. Tsay and Ronngchen. Nonlinear time series analysis. Wiley 2019
2. Enders W. Applied Econometric Time Series. John Wiley & Sons, Inc., 1995.
3. Mills, T.C. The Econometric Modelling of Financial Time Series. Cambridge University Press, 1999
4. Andrew C. Harvey. Time Series Models. Harvester wheatsheaf, 1993.

5. Andrew C. Harvey. The Econometric Analysis of Time Series. Philip Allan, 1990.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. What are the key characteristics of time series data, and why is it important to understand them in the context of analysis and forecasting?
2. How can you pre-process time series data to handle missing values and outliers effectively?
3. What are the different methods available for visualizing time series data, and how can they help in identifying trends and seasonality?
4. Explain the concept of autocorrelation and its significance in time series analysis.
5. What is stationarity in the context of time series data, and why is it important for modeling and forecasting?
6. Compare and contrast the ARIMA and exponential smoothing models in terms of their assumptions and applicability.
7. How can you evaluate the performance of a forecasting model, and what are some commonly used metrics for this purpose?
8. Describe the process of model selection in time series analysis and the factors to consider when choosing an appropriate model.
9. What are the steps involved in building a forecast using the chosen time series model, and how can you interpret the results?

KU8DSECSE413 NATURAL LANGUAGE PROCESSING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE413	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

Course Description:

The course introduces the fundamentals of Natural Language Processing (NLP) from an algorithmic viewpoint. The course provides insight into how machines can deal with NLP. A gist about the various applications of NLP is also discussed.

Course Objectives:

- To introduce the fundamentals of NLP from an algorithmic viewpoint
- To introduce the use of CFG and PCFG in NLP
- To illustrate the process of syntax analysis in NLP
- To explain the fundamentals of speech processing in NLP

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the fundamentals of NLP from an algorithmic viewpoint
CO2	Illustrate the process of syntax analysis in NLP
CO3	Explain the fundamentals of speech processing in NLP
CO4	Discuss various issues that make natural language processing a hard task, and understand how the machines can deal with Natural Languages

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Language: Linguistic Knowledge, Grammar, Language and Thought, computational linguistics vs NLP, why NLP is hard? why is NLP useful? classical problems. Words of Language, Content Words and Function Words, Lexical categories, Regular expressions and automata. Morphology: Morphemes, Rules of Word Formation, Morphological parsing and Finite state transducers. (15 hours)

Module 2: N-grams: simple N-grams, smoothing, Applications, language modeling. Word classes and POS tagging: tag sets, techniques: rule based, stochastic and transformation based. Introduction to Natural Language Understanding - Levels of language analysis - Syntax, Semantics, Pragmatics. (15 hours)

Module 3: Grammars and Parsing - Grammars for Natural Language: CFG, Probabilistic Context Free Grammar, Statistical Parsing. Features and Unification: Feature Structures and Unification of feature structures. Lexical semantics, formal semantics and discourse. WSD, Information retrieval: Boolean, vector space and statistical models. Knowledge Representation and Reasoning - FOPC, Elements of FOPC. (15 hours)

Module 4: Discourse processing: monologue, dialogue, reference resolution, Conversational Agent. Text coherence. Dialogue acts: Interpretation of dialogue acts, plan inference model, clue-based model. Semantics: Representing meaning, Semantic analysis, Lexical semantics. Applications: Machine Translation, Natural Language Generation: architecture, surface realization and discourse planning. (15 hours)

Module X : Deep Learning for NLP, Neural Machine Translation (NMT), Sentiment Analysis and Opinion Mining, Natural Language Generation (NLG), Ethical and Social Implications of NLP (15 hours)

Core Compulsory Readings

1. Daniel Jurafsky and James H Martin. Speech and Language Processing.

Core Suggested Readings

1. Hobson Lane, Cole Howard, Hannes Hapke. Natural Language Processing in Action
2. Victoria fromkin, Robert Rodman and Nina Hyams, An Introduction to language, Tenth Edition. Downloadable freely at: https://ukhtt3nee.files.wordpress.com/2019/04/an_introduction_to_language.pdf

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes

1. How does computational linguistics differ from Natural Language Processing (NLP), and what are the main challenges that make NLP difficult?
2. Discuss the significance of NLP and its usefulness in various domains. Highlight some classical problems encountered in NLP research and applications.
3. Explain the concept of N-grams and their role in language modeling. Discuss common techniques used for smoothing N-gram models.

4. What are word classes and part-of-speech (POS) tagging? Describe the different techniques for POS tagging, including rule-based, stochastic, and transformation-based methods.
5. Compare and contrast Context-Free Grammars (CFG) and Probabilistic Context-Free Grammars (PCFG) in the context of natural language parsing.
6. Discuss the role of feature structures and unification in grammar formalisms, and explain their significance in linguistic analysis.
7. Explain the challenges involved in discourse processing, particularly in the context of reference resolution and dialogue acts interpretation.
8. Describe the architecture of a Natural Language Generation (NLG) system and its components, including surface realization and discourse planning. Provide examples of NLG applications such as machine translation and dialogue generation.

KU8DSECSE414 FUZZY SYSTEMS AND LOGIC

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE414	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

Fuzzy Systems and Logic delve into the theory and applications of fuzzy set theory and fuzzy logic, which are essential tools for handling uncertainty and imprecision in various engineering and computing domains. This course provides students with a comprehensive understanding of fuzzy systems, fuzzy reasoning, and their applications in decision-making, control systems, and pattern recognition.

Course Objectives:

- To introduce students to the fundamental concepts of fuzzy set theory and fuzzy logic.
- To enable students to design and implement fuzzy systems for real-world applications.
- To develop students' skills in fuzzy reasoning, inference mechanisms, and fuzzy control systems.
- Familiarize advanced topics in fuzzy systems, such as fuzzy clustering, fuzzy neural networks, and fuzzy decision-making.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamental concepts of fuzzy systems.
CO2	Familiarize concepts of Fuzzification and defuzzification.
CO3	Familiarize students with fuzzy logic.
CO4	Students can design and implement fuzzy systems.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Fuzzy systems - Historical perspective, Uncertainty and Information, fuzzy sets and membership, Chance vs Fuzziness. Classical and non-classical sets: Introduction, Crisp set: Definition, Properties of crisp set, Operations on crisp set, Applications. (15 Hours)

Module 2: Classical relations and fuzzy relations: Crisp relations, fuzzy relations, Tolerance and equivalence relation, fuzzy tolerance and equivalence relation, value assignment.(15 Hours)

Module 3: Properties of membership function, fuzzification and defuzzification: Features of membership function, various forms, fuzzification, defuzzification of crisp sets, λ cuts for fuzzy relations, defuzzification to scalars.(15 Hours)

Module 4: Logic and Fuzzy systems: Classical logic, proof, Fuzzy logic, approximate reasoning, other forms of the implication operation. Natural language, Linguistic hedges, Fuzzy rule-based systems, Graphical techniques for inference.(15 Hours)

Module X : Fuzzy Clustering and Pattern Recognition, Fuzzy neural networks, Fuzzy decision-making and optimization, Fuzzy time series analysis.(15 Hours)

Core Compulsory Readings

1. Ross, Fuzzy Logic with Engineering Applications, 3rd Edn, Wiley India.
2. George J, Klir, Yuan," Fuzzy sets and Fuzzy logic – Theory and Applications", PHI,2009

Core Suggested Readings

1. Hajek P, Metamathematics of Fuzzy Logic. Kluwer, 1998
2. Rajasekharan and Viajayalakshmipai, Neural Networks, Fuzzy Logic and Genetic Algorithm, PHI, 2003.
3. Sivanandan and Deepa, Principles of Soft Computing, John wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Sample Questions to test Outcomes.

1. What is fuzzy logic, and how does it differ from traditional binary logic?
2. Can you explain the concept of membership functions in fuzzy logic?
3. How are fuzzy sets defined and represented in fuzzy logic?
4. What is the role of fuzzy inference systems in decision making?
5. Can you describe the Mamdani and Sugeno fuzzy inference methods?

6. How can fuzzy logic be applied in pattern recognition and classification tasks?

KU8DSECSE415 WIRELESS AD HOC NETWORKS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	DSE	400	KU8DSECSE415	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	2	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course introduces the basics of cryptography and network security. Fundamental concepts of cryptography the fundamental concepts of main concepts of networking to the learner. TCP/IP network model is taken as the basis for the discussion. The course provides the learner a brisk walk through the fundamentals concepts of symmetric and public key cryptography are outlined in the course. The course also deals with the basic topics on network security.

Course Objectives:

- Explain fundamental principles of Ad-hoc Networks
- Discuss a comprehensive understanding of various routing protocols in Ad-hoc networks
- Outline current and emerging trends in Transport Layer and Security Protocols for Ad-hoc Networks.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Identify the basic concepts of Wireless Ad Hoc Networks
CO2	Explain various routing protocols in Wireless Ad Hoc Networks
CO3	Explain fundamentals of multicast routing protocols in Ad-hoc Wireless Networks
CO4	Describe the basics of Transport Layer and Security Protocols for Ad-hoc Networks

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Wireless Ad-hoc Networks: Cellular and Ad Hoc Wireless Networks - Applications - Issues - Ad-hoc Wireless Internet. MAC Protocols for Ad-hoc Wireless Networks: Design Issues - Design Goals - Classification (Overview only) - (15 Hours)

Module 2: Routing Protocols for Ad-hoc Wireless Networks: Design Issues - Classification - Table Driven Routing Protocols - On-Demand Routing Protocols - Hybrid Routing Protocols - Hierarchical Routing Protocols(15 Hours)

Module 3: Multicast Routing in Ad-hoc Wireless Networks: Design Issues - Operation - - An Architecture Reference Model - Classification - Tree-Based Multicast Routing Protocols (Bandwidth-Efficient, Zone Routing, Multicast Core-Extraction Distributed) (20 Hours)

Module 4: Transport Layer and Security Protocols for Ad-hoc Networks: Design Issues - Design Goals - Classification of Transport Layer Solutions - TCP over Transport Layer Solutions: Reasons for Bad Performance of TCP in Ad Hoc Wireless Networks - TCP-F - TCP with Explicit Link Failure Notification - TCP-BuS. (20 Hours)

Module X : Directional MAC Protocols for Ad Hoc Wireless Networks - Mesh-Based Multicast Routing Protocols (On-Demand, Dynamic Core-Based, Forwarding Group) - Power-Aware Routing Protocols - Security in Ad-hoc Wireless Networks: Requirements - Issues and Challenges - Network Security Attack (5 Hours)

Core Compulsory Readings

1. Williams Stallings Cryptography and Network Security: Principles and Practice, Pearson Education, 7th Edition

Core Suggested Readings

1. William Stallings, Network Security Essentials Applications and Standards, 4th Edition, Pearson India, ISBN: 8131761754.

2. Atul Kahate, Cryptography and Network Security, 3rd Edition, Tata McGrawHill Publishing, ISBN: 9789332900929.

3. Eric Maiwald, Fundamental of Network Security, 1st Edition, Tata McGraw - Hill Education, 0071070931.

4. Charlie Kaufman, Radia Perlman and Mike Speciner, Network Security: Private Communication in Public World, 2nd Edition, PHI Learning Pvt Ltd, ISBN: 8120322134.
5. Charles P. Pfleeger, Security in Computing, 4th Edition, Prentice-Hall International, 2006.

6. Christ of Paar, Jan Pelzl& Bart Preneel, Understanding Cryptography: A Textbook for Students and Practitioners, 1st Edition, Springer, 2010.

7. Bruce Schneider, Applied Cryptography Protocols, Algorithms, and Source Code in C", 2nd Edition, John Wiley & Sons, 2007

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Team Learning

MODE OF TRANSACTION

- Lecture, Seminar, Demonstration, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Semester IX

KU09DSCCSE502 APPLIED DIGITAL SIGNAL PROCESSING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	DSC	500	KU09DSCCSE502	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

The course "Applied Digital Signal Processing" covers theory and practical applications of digital signal processing (DSP). Students learn fundamental concepts such as discrete-time signals, Fourier analysis, and digital filtering. Through theoretical instruction and hands-on projects, they gain skills to design filters, perform spectral analysis, and process digital signals for various applications. Advanced topics include adaptive filtering and wavelet transforms, with applications in telecommunications, audio processing, and biomedical engineering. By course end, students are proficient in analyzing, manipulating, and interpreting digital signals in real-world scenarios.655

Course Objectives:

- Provide a comprehensive understanding of DSP fundamentals and speech processing techniques.

- Explore speech analysis, including feature extraction and recognition methods.
- Introduce speech forensics, speaker identification, and voice biometrics.
- Equip students with skills to enhance speech communication and understand DSP applications.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Proficiency in understanding the principles and applications of digital signal processing (DSP) fundamentals.
CO2	Mastery of speech processing techniques, including speech analysis, feature extraction, and recognition.
CO3	Competence in applying speech forensics and speaker identification methods, including voice biometrics.
CO4	Ability to enhance speech communication through coding, compression, noise reduction, and synthesis methods, while understanding DSP applications in communication systems.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Introduction to Digital Signal Processing (DSP): Overview of Digital Signal Processing, Discrete-time signals and systems, Sampling and quantization, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Z-transform and its applications, Introduction to filter design techniques (FIR and IIR filters) (15 Hours)

Module 2: Speech Processing Fundamentals: Introduction to Speech Processing, Speech production mechanism, Speech analysis: Time-domain and Frequency-domain analysis, Feature extraction techniques for speech signals, Short-time Fourier Transform (STFT) and Spectrogram analysis, Mel-frequency cepstral coefficients (MFCCs) and their applications in speech recognition (15 Hours)

Module 3: Speech Forensics and Speaker Identification: Overview of Speech Forensics, Speech feature extraction for forensic analysis, Speech signal embedding techniques, Steganography and watermarking in speech signals, Speaker identification and verification techniques, Voice biometrics and its applications (20 Hours)

Module 4: Speech Communication and Enhancement: Speech coding and compression techniques, Speech synthesis methods, Noise reduction and speech enhancement algorithms, Speech quality assessment, Speech communication protocols and systems, Applications of DSP in speech communication systems (15 Hours)

Module X :

Deep Learning for Speech Processing: Introduction to deep neural networks (DNNs) for speech recognition, Convolutional Neural Networks (CNNs) for speech analysis, Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks for sequential modeling in speech processing, Attention mechanisms in speech processing tasks

Multimodal Speech Processing: Integration of speech with other modalities such as text, image, and video, Fusion techniques for multimodal speech processing, Applications of multimodal speech processing in assistive technologies, healthcare, and human-computer interaction

Real-world Applications and Case Studies

- Industry applications of speech processing in areas such as telecommunications, automotive, robotics, and entertainment
- Case studies on the deployment of speech processing technologies in various domains
- Emerging trends and future directions in applied digital signal processing for speech processing and communication (10 Hours)

Core Compulsory Readings

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Publisher: Pearson Education, Edition: 4th Edition (or the latest edition available)

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes

1.What are the key concepts of digital signal processing (DSP), and how do they differ from analog signal processing?

2. Explain the significance of discrete-time signals and systems in DSP, and discuss their advantages over continuous-time counterparts.
3. Describe the speech production mechanism and its relevance to speech processing.
4. How do time-domain and frequency-domain analysis techniques contribute to speech analysis, and what are their respective advantages?
5. What are the key components of speech forensics, and how are they utilized in forensic analysis?
6. Discuss the principles of speaker identification and verification techniques, including voice biometrics.
7. Explain the importance of speech coding and compression techniques in communication systems.
8. How do noise reduction and speech enhancement algorithms contribute to improving speech communication quality?

KU09DSCCSE503 DIGITAL IMAGE PROCESSING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	DSE	500	KU09DSCCSE503	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

Course Description:

This course provides a comprehensive introduction to digital image processing, covering fundamental concepts and techniques essential for understanding and manipulating digital images. Throughout the course, students engage in practical exercises and projects to apply their knowledge and skills to real-world image processing tasks. By the end of the course, students will have a strong foundation in digital image processing principles and techniques, preparing them for further study or application in fields such as computer vision, medical imaging, and multimedia analysis.

Course Objectives:

- Understand the fundamental concepts of digital image formation, including visual perception, image representation, and color models.
- Gain proficiency in performing basic image operations on a pixel basis, including point operations, contrast stretching, clipping, thresholding, and histogram equalization.
- Learn advanced image processing techniques, including image segmentation methods such as edge detection, thresholding, and region-oriented segmentation.
- Engage in practical exercises and projects to apply learned concepts and techniques to real-world image processing tasks.
- Prepare for further study or application in fields such as computer vision, medical imaging, multimedia analysis, and more, with a strong foundation in digital image processing principles and techniques.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Comprehensive understanding of digital image fundamentals
CO2	Solid foundation in basic image processing techniques
CO3	Equip students with a comprehensive understanding of image segmentation techniques and their applications
CO4	Provide students with a deep understanding of various techniques used to represent and describe digital images

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Digital Image Fundamentals: - Visual perception-Image representation and modelling- Color Models and Color Spaces: RGB, CMYK, HSL, HSV, Lab, etc. Image sampling and quantization:- Basic concepts in sampling and quantization-spatial and grey level resolution- Relationships between pixels:- neighbours of pixel- Adjacency, connectivity, regions and boundaries-Distance measures-Image operations on pixel basis-Image Enhancement in the spatial domain:- Point operations - contrast stretching - clipping and thresholding - digital negative intensity level slicing -Histogram modelling - histogram equalization -modification (20 Hours)

Module 2: Digital Image Fundamentals:- Visual perception-Image representation and modelling- Image sampling and quantization:- Basic concepts in sampling and quantization-spatial and grey level resolution-Relationships between pixels:- neighbours of pixel- Adjacency, connectivity, regions and boundaries-Distance measures-Image operations on pixel basis-Image Enhancement in the spatial domain:- Point operations - contrast stretching - clipping and thresholding - digital negative intensity level slicing - Histogram modelling - histogram equalization -modification (20 Hours)

Module 3: Image Segmentation: -Detection of discontinuities: -point detection-line detection-edge detection- combined detection. Edge Linking and boundary detection: - local processing-global processing via the Hough Transform-Global processing via Graph-Theoretic Techniques. Thresholding: -simple global thresholding-Optimal Thresholding. Region-oriented segmentation: - Basic formulation- region growing by pixel aggregation-Region splitting and merging (20 Hours)

Module 4: Representation and Description: Representation – Chain codes, Polygonal approximations, Signatures, Boundary segments, Skeletons. Boundary descriptors: simple descriptors, shape numbers, Fourier descriptors, Statistical moments. Regional descriptors - Simple and topological descriptors, texture. Principal components for description (20 Hours)

Module X: Deep Learning-Based Image Super-Resolution, Generative Adversarial Networks (GANs) for Image Synthesis, Attention Mechanisms in Image Processing, Graph-Based Image Processing, Domain Adaptation and Transfer Learning in Image Processing, Deep Reinforcement Learning for Image Processing, Explainable AI (XAI) in Image Processing (10 Hours)

Core Compulsory Readings

1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods, 3rd Edition
2. Fundamentals of Digital Image Processing by Anil K Jain
3. Digital Image Processing by William K Pratt

Core Suggested Readings

1. Rosenfield Azriel, Kak Avinash C, "Digital Picture Processing", Academic Press Inc.
2. Bernd Jahne, Digital Image Processing 5 th revised and extended edition, Springer
3. B Chanda, D Dutta Majumder, Digital Image processing and Analysis, PHI.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes.

1. Discuss the importance of image sampling and quantization in digital image processing. What are the key considerations in these processes?
2. What is the significance of spatial resolution in digital images? How does it affect image quality?
3. Define histogram equalization. How does it improve the contrast of an image?
4. Discuss the process of region-oriented segmentation and its applications.
5. What are boundary descriptors, and how are they used in image analysis?
6. Describe the process of principal component analysis (PCA) for image description.
7. How are Fourier descriptors used in image representation and description?
8. Discuss the challenges and advantages of using topological descriptors in image representation.

9. Explain the concept of optimal thresholding. How is it different from simple global thresholding?
10. Explain the concept of edge detection in image segmentation. What are some common edge detection algorithms?

KU09DSCCSE504 HUMAN COMPUTER INTERACTION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	DSC	500	KU09DSCCSE504	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for practical**

Course Description:

This course primarily focuses on the fundamental theories, practical methodologies, and concepts of Human-Computer Interaction (HCI) which is a nebulous field involving AI, Psychology, Cognitive Science, Ubiquitous Computing, Multimodal Interaction, Affective/Cognitive Computing, and many more.

Course Objectives:

- To familiarize the theoretical foundations and concepts of HCI.
- To impart fundamental knowledge for designing and analysing

interactive systems with an emphasis on ergonomics and human factors.

- To provide a deeper understanding of user experience and user-centred design.
- Give basic ideas on various aspects and developments in the field of interaction design and human computer interaction.

Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the fundamentals of HCI and user-centred design principles.
CO2	Know about the basic physiological, perceptual, and cognitive components of human learning and memory.
CO3	Develop an understanding of social and emotional interaction and various interfaces available.
CO4	Familiarize with the cognitive framework and fundamental HCI models.
CO5	Learn about task analysis, various task analysis techniques and dialog design.
CO6	Gain knowledge on interaction design and major design rules.
CO7	Know in-depth about various design evaluation techniques and prototyping.
CO8	Gain knowledge on designing and conducting experimental evaluations in HCI along with selecting appropriate experimental factors and variables, utilizing subjective measurements, and applying statistical analysis methods.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔
CO5	✔	✔	✔	✔	✔
CO6	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓
CO8	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: *Introduction to HCI:* What is HCI; Difference between HCI and interface design; HCI - relation to ergonomics or human factors; Problems and challenges; User Centred Design (UCD), Basic elements of UCD

Human Factors and Ergonomics: Input-Output channels; Human cognitive process and information processing (sensation, perception, attention, cognition, human information processing and execution); Human memory, and LTM; Forgetting: Is memory loss due to decay, interference, or access problems?; Information retention and comprehension: Recall vs. recognition; Problem solving and decision making; Human cognitive abilities and limitations; Stress and mental workload; Assessment techniques - cognitive task analysis, cognitive workload measurement; Anthropometry and workspace design; Work physiology - muscle structure and metabolism, circulatory and respiratory systems, workload measurement (20 hours)

Module 2: *Interaction & Interfaces:* Social interaction - face-to-face conversations, remote conversations, co-presence, social engagement; Emotional interaction - emotions and the user experience, expressive interfaces and emotional design, affective computing and emotional AI, persuasive technologies and behavioural change; Types of interfaces - command-line, graphical, multimedia, virtual reality, web, mobile, appliances, pen, voice, touch, gesture, haptic, multimodal, shareable, tangible, augmented reality, wearables, robots and drones, brain-computer interfaces, and smart interfaces (20 Hours)

Module 3: *HCI Models:* Cognitive frameworks: mental models, gulfs of execution and evaluation, information processing, distributed cognition, external cognition, and embodied interaction; Cognitive models - goal and task hierarchies, linguistic models, physical and device models; Mathematical models for human motor behavior: predictive models - Hick-Hymans Law, Keystroke-Level Model, Fitts' Law, descriptive models - Key-Action Model, Three-State Model of Graphical Input, Guiard's Model of Bimanual Skill; Probabilistic graphical models for predicting user behavior – Hidden Markov Model

Task Analysis & Dialog Design: Introduction to Task Analysis; Techniques for task analysis - Hierarchical task analysis (HTA), Knowledge-based task analysis, entity–relationship-based task analysis; Introduction to formalism in dialog design; State transition networks, state charts and petri nets in dialog design (20 Hours)

Module 4: *Interaction Design & Design rules:* Introduction to Interaction Design; Basics of User Experience and User centred approach; Accessibility, Usability concepts; Lifecycle model for interaction design; Conceptual Design;

Shneiderman's eight golden rules; Norman's seven principles; Norman's model of interaction; Nielsen's ten heuristics.

Evaluation of Design and Prototyping: Two forms of design evaluation - evaluation without users (through expert analysis), and evaluation with users (through user participation); Types of expert analysis based evaluation – cognitive walkthroughs, heuristic evaluation, and model based evaluation; Types of user-based evaluation - usability testing (formative and summative), conducting experiments, field studies, inspections, analytics and A/B testing, predictive models (Fitts law, and HickHyman law); Approaches to user-based evaluation; Prototyping - characteristics of a prototype, Lo-fi and Hi-Fi prototypes, prototyping techniques and tools - Design low-fidelity and high-fidelity prototypes in design tool Figma, Wizard of Oz technique (20 Hours)

Module X:

Empirical methods: Experimental Evaluation in HCI: Experiment design and data analysis; Experimental factors and variables; Different human measurements - objective, behavioural, subjective, and physiological measures; Subjective measurements - measurement scales, questionnaire design; Descriptive statistics; Statistical analysis - types of data, normal distribution, hypothesis testing - non-parametric tests & parametric tests, correlation and regression, chi square, ANOVA (10 Hours)

Core Compulsory Readings

1. Human-Computer Interaction (3rd Edition), Dix, Finlay, Abowd and Beale, Pearson, 2003.
2. Designing the User Interface: Strategies for Effective Human-Computer Interaction (5th Edition), Shneiderman, Plaisant, Cohen, and Jacobs, Addison Wesley, 2009.
3. Interaction Design (3rd Edition), Preece Jenny, Rogers Ivonne, Sharp Helen, John Wiley and Sons, 2011.

4. An Introduction to Human Factors Engineering (2nd Edition), Wickens, C. D., Gordon, S. E., Liu, Y., & Lee, J, Pearson, 2004.
5. Kellogg, R.T., Fundamentals of Cognitive Psychology, Sage Publications, 2012.
6. Kaber, D.B. and Boy, G., Advances in Cognitive Ergonomics, CRC Press, New York, 2010.
7. HCI Models, Theories, and Frameworks Toward a Multidisciplinary Science, Carroll, J. M. (Ed.), Elsevier Science, 2003.
8. Probabilistic graphical models. Advances in Computer Vision and Pattern Recognition, Sucar, L. E, Springer London, 2015

Core Suggested Readings

1. Understanding your users: A practical guide to user requirements methods, tools, and techniques, Courage, C., & Baxter, K, Gulf Professional Publishing, 2005.
2. Research Methods in Human-Computer Interaction (2nd Edition), Lazar, J., Feng, J. H., & Hochheiser, H, Morgan Kaufmann Publishers, 2017.
3. Human-Computer Interaction an Empirical Research Perspective, MacKenzie, I. S., Morgan Kaufmann Publishers, 2013.
4. Harris, D., Engineering Psychology and Cognitive Ergonomics, EPCE 2011 Proceedings. HCI International 2011, Springer, Germany, 2011.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab , Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical

Sample Questions to test Outcomes.

1. Define Human-Computer Interaction (HCI) and the three components of HCI.
2. Explain in detail about the human memory and factors affecting forgetting.
3. Discuss the key differences between KLM and GOMS.
4. How to measure difficulty of a target acquisition task?
5. What is throughput? How it can be used in the design of interactive systems?
6. Explain the Hick-Hyman law. Describe the predictive formulation of the law.
7. Discuss Nielsen's ten heuristics for user interface design.
8. Why we need formal dialog representation?
9. Mention the elements of a (classical) Petri Net. How Petri Nets work?
10. Mention with brief explanation the main stages of an interactive system design life cycle.
11. Explain the difference between formative and summative HCI research methods.
12. Explain the different prototyping techniques used in HCI. In which stages of the design cycle these are used and why?
13. Discuss the wizard of oz approach. Can we evaluate any design with this approach?
14. Discuss the different types of measurement techniques.
15. Discuss the significance of statistical data analysis in empirical research.

KU09DSCCSE505 ADVANCED DATA STRUCTURE AND ALGORITHMS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	DSC	500	KU09DSCCSE505	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: Data Structures are commonly used in many program designs. The study of data structures, consequently, truly forms the central course of any curriculum in Computer Science. This course offers a deep understanding of the important concepts of data structures. The students are advised to go for implementation of algorithms so that; once the data structures are programmed, they can be subsequently used in many different applications.

Course Objectives:

- Understand the concept of data structures and its relevance in computer science.
- Familiarize with selected linear and nonlinear data structures.
- Understand the concept of trees in detail.
- Appreciate the concept of Graph in detail.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Knowledge about the scientific relevance of linear data structures
CO2	Knowledge to implement nonlinear data structures
CO3	Familiar with the applications of classic data structures.
CO4	Ability to design sorting and searching algorithms

Mapping of COs to PSOs

	PSO1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Data structures: Definition and classification. Linear data structure: Array- operations, polynomial representation with arrays, applications of arrys; concept of recursion, types of recursion. Case study with Tower of Hanoiproblem. Multidimensional arrays, sparse matrices Stack: operations on stack. Application of stack i. postfix expression evaluation. ii. conversion of infix to postfix expression. Queues: operation on queue. Various queue structures- circular queue, dequeue and priority queue. Application of queue: job scheduling (20 Hours)

Module 2: Linked list: single linked list, structure and implementation; operations – traversing, add new node, delete node, reverse a list, search and merge two singly linked lists. Circular linked list– advantage. Queue as circular linked list. Doubly linked list, operations – add/delete nodes, advantages. Applications of linked lists- Sparse matrix manipulation, polynomial representation, dynamic storage management. Memory representation- Fixed block storage and Variable block storage (20 Hours).

Module 3: Tables- rectangular tables, jagged tables, inverted tables. Hash table- Hashing techniques, Collision resolution techniques, closed hashing, open hashing, comparison of collision resolution techniques. Tree- basic terminologies and properties; representation of binary tree- i) linear representation of a binary tree ii) linked representation of a binary tree, operations on binary tree- insertion, deletion and traversal; type of binary trees- expression tree, binary search tree, heap tree, threaded binary tree, height balanced binary tree, red black tree, splay tree, weighted binary tree, decision trees. Forest, B tree indexing, operations on a B tree, lower and upper bonds of a B tree, B+ tree indexing and Trie tree indexing. Tree traversal: in order, pre order and post order traversals. Binary search tree. Application of tree, AVL tree, Huffman algorithm (20 Hours).

Module 4: Graphs: Graph terminologies, representation of graphs- set representation, linked representation and matrix representation. Operations on graphs- i) operations on linked list representation of graphs, ii) operations on matrix representation of graphs. Applications of graph structures- Shortest path problem, topological sorting, MST, connectivity in a graph, Euler's and Hamiltonian Circuits. BDD and its applications- conversion of decision tree into BDD. Representations and operations of sets: Hash table representation of sets, linked list representation of sets, tree representation of sets and bit vector representation of sets. Sorting Techniques: Insertion sort, Bubble sort, Selection sort, Quick sort and Merge sort. Comparison of sorting algorithms. Searching: basic terminologies, linear search: linear search with array, linear search linked lists. Non- linear search techniques, binary search, binary tree searching. (20 Hours)

Module 5 (Teacher Specific): Advanced Lists - n-ary Trees - K -Dimensional Trees (10 Hours)

Core Compulsory Readings

1. Aho, A.Y., Hopcroft, J.E., and Ullman, J.D. 1983. Data Structures and Algorithms. Addison-Wesley, Reading, MA

2. Samanta, Classic Data structures, Second Edition, PHI

3. Sahni and Mehta, Fundamentals of Data Structures in C++, 2^{nd}Edn, University Press

Core Suggested Readings

1.Donald Knuth, The Art of Computer Programming, Fundamental Algorithms, Volume- 1

2. Thomas H Cormen, Charles E Leiserson, and Ronald L Rivest, Introduction to Algorithms, 3rd Edition, Prentice Hall of India Private Limited, New Delhi.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes.

1. Discuss different operations carried out on linked lists
2. What is the *postfix* form of **((111 + X) ↑ Y) * ((Z – 101) / 11)**

3. Write the algorithm to demonstrate the *insertion* and *deletion* operations on a *Circular Queue*.

4. Write an algorithm to insert a node in the front side of a double linked list.

KU09DSCCSE506 ADVANCED COMPUTER NETWORKS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
IX	DSC	500	KU09DSCCSE506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course is intended to provide the learner an exposure to various research areas in Computer Networks. Topics covered include routing protocols, QOS and security in MANET, applications of Machine Learning in MANET Routing Protocols, challenges and opportunities in the areas of edge computing and software defined networks.

Course Objectives:

- Provide a exposure to the research issues and challenges in various areas such as protocols, QOS and security in MANET, applications of

Machine Learning in MANET Routing Protocols, challenges and opportunities in the areas of edge computing and software defined networks

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the issues and challenges in designing routing protocols in MANET
CO2	Explain the issues and challenges in incorporating QOS in MANET
CO3	Explain the issues and challenges in MANET security
CO4	Describe the applications of Machine Learning in MANET Routing Protocols, challenges and opportunities in the areas of edge computing and software defined networks

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Module 1: Routing Protocols for MANETS**:** Ad Hoc Wireless Networks: Introduction, Classification: Types (Proactive, Reactive, Hybrid, Geographic, Multipath, QoS Aware, Power Aware, Hierarchical, Location Based, Trust based, Associativity- Based, Signal Stability Based Adaptive, Delay Tolerant and Cross Layer), Features, Merits and Demerits. Design Issues for Routing Protocols in MANET. Overview of Multicast Routing in MANETs. Case study: Features, Methodology, Design and Issues of DSDV, DSR, AODV, and ZRP. (20 Hours)

Module 2: Quality of Service in Mobile Ad-Hoc Networks: Introduction - Real Time Traffic Support in Ad-Hoc Networks – QoS Parameters in Ad-Hoc Networks. Issues and Challenges in Providing QoS in Ad-Hoc Wireless Networks - Classification of QoS Solutions: MAC Layer Solutions, Network Layer Solutions. Design Choices for Providing QoS Support. QoS Framework for Ad-Hoc Wireless Networks. (20 Hours)

Module 3: MANET Security: Security issues and Challenges, Attacks, Overview of Secure Routing protocols. Ad hoc network security – Link layer, Network layer. Trust and key management. Self policing MANET – Node Misbehaviour, secure routing, reputation systems. (20 Hours)

Module 4: Applications of Machine Learning in MANET Routing Protocols. Edge Computing: Concepts, Challenges and Opportunities. Cloud Computing: Edge Computing: Concepts, Challenges and Opportunities. Software Defined Networks: Concepts, Working Principle and Methodology - Challenges and Opportunities (20 Hours)

Module 5 (Teacher Specific): Mobility Management in MANET: Dynamic topology and Node Mobility, Mobility Models and their Impact **-** QoS Models for Mobile Ad-Hoc Networks - Flexible QoS models for Mobile Ad-Hoc Networks - Energy Management: Need, Classification, Battery Management Schemes - Transmission Management Schemes- System Power Management Scheme (10 Hours)

Core Compulsory Readings

1. Jochen H. Schiller, Mobile Communications, Second Edition, Pearson Education India
2. William Lee, Mobile Communications Engineering: Theory and Applications, McGraw Hill Education
3. C. Siva Ram Murthy and B. S. Manoj, Ad hoc Wireless Networks, Pearson Education, 2nd Edition, reprint 2005
4. William Stallings, Wireless Communications and Networks, Prentice Hall, 2004
5. Suchit Purohit, Mobile Computing, Available at Mobile Computing – Simple Book Publishing (inflibnet.ac.in)
6. Dharma P. Agrawal, Introduction to Wireless and Mobile Systems, 3rd Edition, Cengage India Private Limited
7. Radhika Ranjan Roy, Handbook of Mobile Ad Hoc Networks for Mobility Models, Springer New York, NY
8. Subir Kumar Sarkar, G. Basavaraju, C. Puttamadappa, Ad Hoc Mobile Wireless Networks -Principles, Protocols and Applications, Auerbach Publications, Taylor & Francis Group
9. Dr. Makarand Shahade, Mobile Ad Hoc Network : A Reliable Power Routing Scheme for Mobile Ad Hoc Network, Notion Press (6 February 2023), Notion Press Media Pvt Ltd
10. Murthy C. Siva Ram, and Manoj B. S., Ad Hoc Wireless Networks: Architectures and Protocols, Pearson, 1st Edition
11. Vu Khanh Quy, Vi Hoai Nam, Dao Manh Linh, Le Anh Ngoc, Routing Algorithms for MANET-IoT Networks: A Comprehensive Survey, Wireless Personal Communications (2022) 125:3501–3525, Available at https://link.springer.com/article/10.1007/s11277-022-09722-x
12. Ghosh, R.K. (2017). Routing Protocols for Mobile Ad Hoc Network. In: Wireless Networking and Mobile Data Management. Springer, Singapore. https://doi.org/10.1007/978-981-10-3941-6_7,

13. George Aggelou, Mobile Ad Hoc Networks, McGraw Hill Education (22 August 2009)
14. Stefano Basagni, Marco Conti, Silvia Giordano, Ivan Ivan Stojmenovic, Mobile Ad Hoc Networking, 2nd Edition, The Cutting Edge Directions, Wiley
15. R. Kumar Ahuja, Naina and J. Jadon, Quality of service in MANETS, 2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon), Bengaluru, India, 2017, pp. 271-276, doi: 10.1109/SmartTechCon.2017.8358381.
16. Sra, P., Chand, S. QoS in Mobile Ad-Hoc Networks. Wireless Pers Commun 105, 1599–1616 (2019). https://doi.org/10.1007/s11277-019-06162-y
17. Lidong Zhou and Zygmunt J. Haas, Securing Ad Hoc Networks, Available at adhoc.pdf (microsoft.com)
18. Gopala Krishnan, C., Nishan, A.H., Gomathi, S. et al. Energy and Trust Management Framework for MANET using Clustering Algorithm. Wireless Pers Commun 122, 1267–1281 (2022). https://doi.org/10.1007/s11277-021-08948-5
19. Toh C. K., Ad Hoc Mobile Wireless Networks Protocols and Systems", Prentice Hall, PTR, 2001.
20. PrasantMohapatra, Srikanth. V. Krishnamurthy,Ad - Hoc Networks Technologies and Protocols, Springer 2006
21. Yi-Bing and Imrich Chlamtac, Wireless and Mobile Networks Architectures, John Wiley & Sons, 2008

Core Suggested Readings

1. Current Literature

TEACHING LEARNING STRATEGIES

- Hands-on-oriented teaching, collaborative learning, case studies and project presentations, peer-led discussions.

MODE OF TRANSACTION

- Lecture, seminar, discussion, audio and video presentation, demonstration, practical assignments, and exercises.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes.

1. Explain any two types of routing protocols and compare their features
2. Discuss the issues and challenges in providing QoS in Ad-Hoc Wireless Networks
3. Prepare a short note on self policing MANET
4. Explain the working principle of SDN
5. Explain energy management in MANET

Semester X

S10 - List of Discipline Specific Electives (DSE) (POOL H)

KU10DSECSE506 BIOMETRIC IMAGE PROCESSING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This comprehensive course in digital image processing and biometrics covers fundamental concepts and advanced techniques essential for understanding and working with digital images and biometric data.

Course Objectives:

- Understand the fundamental concepts of digital image representation, including pixel intensity, color models, and spatial resolution.
- Gain a deep understanding of fundamental morphological image processing concepts and operations.
- Understand the process of characterizing biometric data through minutiae extraction techniques, including histogram equalization and binarization.
- Master the detection of minutiae points in hand and iris biometrics and understand their significance in biometric matching.
- Gain knowledge about fusion strategies in biometrics, including multi-biometric systems and various levels of fusion for improving system performance and security.

Course Outcomes:

SL #	Course Outcomes
CO1	Acquire knowledge about Biometric Image Processing
CO2	Familiar with Image enhancement
CO3	Gain knowledge about Hand and Iris Biometrics.
CO4	Familiar with Morphological image processing.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Digital image representation, Fundamental steps in image processing, Elements of digital image processing system, Image sensing and acquisition, Sampling and quantization, Basic relationship between pixels, Transformation technology: Fourier transform - Discrete cosine transform. (20 hours)

Module 2: Image enhancement: Spatial domain methods: Basic grey level transformations - Histogram equalization -Smoothing spatial filter - Sharpening spatial filters - Laplacian, Frequency domain methods: Smoothing and sharpening filters – Ideal - Butterworth - Gaussian filters. Image Segmentation:

Point- Line and edge detection - Thresholding - Global and multiple thresholding, Region splitting and merging. (20 hours)

Module 3:

Morphological image processing: Fundamental concepts and operations, Dilation and Erosion, Compound operations, Morphological filtering, Basic morphological algorithms, Grayscale morphology. 2D and 3D face biometrics: Global face recognition techniques: Principal component analysis - Face recognition using PCA -Linear discriminant analysis - Face recognition using LDA, Local face recognition techniques: Geometric techniques - Elastic graph matching techniques, Hybrid face recognition techniques. 3D Face Image: Acquisition, Pre-processing and normalization, 3D faces (20 hours)

Module 4: Hand and Iris Biometrics: Characterization by minutiae extraction: Histogram equalization, Binarization, Skeletonization, Detection of minutiae, Matching, Performance evaluation, Pre-processing of iris images: Extraction of region of interest - Construction of noise mask – Normalization - Features extraction and encoding - Similarity measures between two iris codes. Fusion in biometrics: Multi-biometrics, Levels of fusion: Sensor level - Feature level - Rank level - Decision level fusion - Score level fusion. (20 hours)

Module X:

Deep Learning for Biometrics: Applications and Challenges, Ethical Considerations in Biometric Data Collection and Usage. Biometric Privacy and Data Protection Regulations. Robustness of Biometric Systems: Vulnerabilities and Mitigation Strategies. Biometric Authentication in IoT and Wearable Devices (10 hours)

Core Compulsory Readings

1. Rafael C Gonzalez, Richard E Woods and Steven L Eddins, "Digital Image Processing", Pearson Education, New Delhi, 2013.

2. Amine Nait Ali and Regis Fournier, "Signal and Image Processing for Biometrics", John Wiley and Sons, UK, 2012.

3. Arun A Ross, KarthikNandakumar and Jain A K, “Handbook of Multi-biometrics”, Springer, New Delhi 2011.

4. Oge Marques, “Practical Image and Video Processing using MATLAB”, John Wiley and Sons, New Jersey, 2011.

Core Suggested Readings

1. Understanding your users: A practical guide to user requirements methods, tools, and techniques, Courage, C., & Baxter, K, Gulf Professional Publishing, 2005.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab
- , Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions to test Outcomes.

1. What are the fundamental steps involved in digital image processing?
2. Explain the process of image segmentation. What are the different techniques for point, line, and edge detection?
3. Describe the process of 3D face image acquisition and pre-processing. What challenges are associated with 3D face recognition?
4. Explain the concept of minutiae extraction in hand and iris biometrics. How does it contribute to biometric authentication?
5. Discuss the concept of morphological filtering and its applications in image processing.
6. Discuss the importance of pre-processing in iris image analysis. What steps are involved in iris image normalization?
7. Describe the process of constructing a noise mask in iris image pre-processing. How does it improve iris recognition accuracy?

8. Compare and contrast the different levels of fusion in biometrics. Which level(s) would you recommend for a high-security system?
9. What are the key performance evaluation metrics used in biometric systems? How do they help assess system reliability?
10. Discuss the challenges and potential solutions in multi-biometric fusion for enhancing system performance and security.

KU10DSECSE507 CYBER FORENSIC

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE507	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course is to provide students with basic knowledge of computer forensics. This course deals with the significance of Computer forensics, Computer Forensics analysis and validation techniques.

Course Objectives:

- Provide basic knowledge of Computer forensics
- Understand the principles, techniques, and methodologies involved in

conducting investigations and forensic analysis of digital evidence in cybercrime cases

- To know the Computer Forensics analysis and validation techniques
- To explain Computer Forensic tools and mobile device forensics.

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the fundamentals of computer forensics
CO2	Illustrate principles of digital evidence collection and preservation
CO3	Explain various aspects of analyzing and validating forensics data
CO4	Explain the legal and ethical aspects of cyber forensics

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Module 1: Computer Forensics Fundamentals: What is Computer Forensics?, Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources / Employment Proceedings, Computer Forensics Services, Benefits of Professional Forensics Methodology, Steps taken by Computer Forensics Specialists. Types of Computer Forensics Technology: Types of Military Computer Forensic Technology, Types of Law Enforcement, Computer Forensic Technology - Types of Business Computer Forensic Technology. (20 hours)

Module 2: Evidence Collection and Data Seizure: Why Collect Evidence? Collection Options obstacles-- Types of Evidence - The Rules of Evidence - Volatile Evidence - General Procedure - Collection and Archiving - Methods of Collection - Artifacts - Collection Steps - Controlling Contamination: The Chain of Custody. Duplication and Preservation of Digital Evidence: Preserving the Digital Crime Scene – Computer Evidence Processing Steps - Legal Aspects of Collecting and Preserving Computer Forensic Evidence Computer Image Verification and Authentication: Special Needs of Evidential Authentication – Practical Consideration -Practical Implementation. Computer Forensics Evidence and Capture: Data Back-up and Recovery. The Role of Back-up in Data recovery. Recovering Graphics Files- Recognizing, locating and recovering graphic files, copyrights issues with graphics. Understanding data compression, identifying unknown file formats. (20 hours)

Module 3: Computer Forensics analysis and validation: Determining what data to collect and analyse, validating forensic data. Addressing data hiding techniques, performing remote acquisitions. Network Forensics: Network forensics overview, performing live acquisitions, developing standard procedures for network forensics, using network tools, examining the honey net project. Processing Crime and Incident Scenes: Identifying digital evidence. Collecting evidence in private sector incident scenes, processing law enforcement crime scenes, preparing for a search, securing a computer incident or crime scene, seizing digital evidence at the scene, storing digital evidence, obtaining a digital hash, reviewing a case. (20 hours)

Module 4: Current Computer Forensic tools: evaluating computer forensic toolneeds, computer forensics software tools, computer forensics hardware tools,validating and testing forensics software E-Mail Investigations: Exploring the role of e-mail in investigation, exploring the roles of the client and server in email, investigating email crimes and violations, understanding email servers, using specialized e-mail forensic tools Cell phone and mobile device forensics: Understanding mobile device forensics, understanding acquisition procedures for cell phones arid mobile devices. (20 hours)

Module X : Cyber law and IT Act (10 hours)

Core Compulsory Readings

1. John R. Vacca, Computer Forensics, Computer Crime Investigation, Second Edition, Firewall Media, New Delhi, 2004
2. Bill Nelson, Amelia Phillips, Frank Enfinger, Christofer Steuart , Computer Forensics and Investigations, Second Indian Reprint , Cengage Learning India Private Limited,2009
3. Britz, Computer Forensics and Cyber Crime – An Introduction, 2ndEdn, Pearson.

TEACHING LEARNING STRATEGIES

- Lecturing

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions

1. Explain cyber forensic
2. what is mobile forensic
3. explain steps taken by cyber forensic experts while collecting the evidence.

KU10DSECSE508 ALGORITHMS IN COMPUTATIONAL BIOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE508	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The course provides an account of the algorithms in Computational Biology. String matching algorithms, which play a remarkable role in Computational Biology, are discussed in detail. The course also introduces sequence alignment in detail.

Course Objectives:

- To understand the algorithms in Computational Biology
- To familiarize with the application of string-matching algorithms
- To provide advanced knowledge about sequence alignment
- To understand the significance of phylogenetic trees

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Explain the basic algorithms in Computational Biology
CO2	Illustrate the application of string matching algorithms and data matrices
CO3	Illustrate the process of sequence alignment
CO4	Explain the basics of multiple sequence alignment

Mapping of COs to PSOs

	PSO1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Basic Algorithms in Computational Biology: Exhaustive search methods and their applications in Computational Biology - Motif finding - Tandem repeats. (20 hours)

Module 2: String matching algorithms: pattern matching in strings, suffix, prefix, factor, substring, exact string matching, exact tandem repeat, Data matrices: Measure of similarity, binary data measures, count data measures, continuous data measures, proximity matrices, string matric, clustering algorithm. (20 hours)

Module 3: Sequence Alignment: Pairwise sequence alignment, Need of Scoring schemes - Penalizing gaps; Scoring matrices for amino acid, PAM Probability matrix and Log odds matrix. BLOSUM. Dot-plot visualization. Needleman - Wunsch algorithm - effect of scoring schemes - e- values. BLAST and FASTA, Smith – Waterman algorithm for local alignment. (20 hours)

Module 4: Multiple sequence alignment: n-dimensional dynamic programming. Tools for MSA: Muscle and T-Coffee. Phylogenetic Algorithms: Clustering-based methods - UPGMA and neighbor-joining, Optimality based: Fitch Margoliash and minimum evolution algorithm; Character-based methods - Maximum Parsimony and Maximum Likelihood methods; Evaluation of phylogenetic trees - significance.(20 hours)

Module 5 : Bioinformatics - Genetic algorithms - DNA computing (10 hours)

Core Compulsory Readings

1. Dan Gusfiled, Algorithms on Strings Trees and Sequences, Cambridge University Press
2. Pevzner P A, Computational Molecular Biology: An Algorithmic Approach, MIT Press Cambridge, MA, 2000

3. John D MacCuish and Norah E. MacCuish, Clustering in Bioinformatics and
Drug Discovery, CRC Press 2011

Core Suggested Readings

1. Richard M. Karp, Mathematical Challenges from Genomics and Molecular Biology, Notices of the American Mathematical Society, vol. 49, no. 5, pp. 544-553
2. Mount D, Bioinformatics: Sequence & Genome Analysis, Cold spring Harbor press
3. Jeremy J. Ramsden, Bioinformatics: An Introduction, Springer
4. Glyn Moody, Digital Code of Life: How Bioinformatics is Revolutionizing Science, John Wiley & Sons Inc
5. Tao Jiang, Ying Xu and Michael Q. Zhang, Current Topics in Computational Molecular Biology, Ane Books
6. Sushmita M and Tinku A, Data Mining Multimedia, Soft Computing and Bioinformatics, John Wiley & Sons, Inc., 2003
7. Andrzej K. Konopka and M. James C. Crabbe, Compact Handbook of Computational Biology, CRC Press.
8. Bellman R E, Dynamic Programming, Princeton University Press
9. Needleman S B and Wunsch C D, A General Method Applicable to the Search for Similarities In the Amino Acid Sequence of two Proteins, J. Mol. Biol., 48 (1970) 443–453
10. Smith T F and Waterman M S, Identification of Common Molecular Subsequences, J. Mol. Bio. 147 (1981) 195–197
11. Watson J D and Crick F H C, A Structure for Deoxyribose Nucleic Acid, Nature, 171 (1953) 737–738

TEACHING LEARNING STRATEGIES

- Lecturing

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

KU10DSECSE509 VISUAL CRYPTOGRAPHY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE509	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The Internet is the fastest growing communication medium and an essential part of the infrastructure nowadays. To cope with the growth of the internet, it has become a constant struggle to keep the secrecy of information as and when profits are involved. It is termed as protecting the copyright of data. To provide secrecy and copyright of data, many of the steganographic techniques have been developed. Visual cryptography is a cryptographic technique which allows visual information (pictures, text, etc.) to be encrypted in such a way that the decrypted information appears as a visual image. It operates by splitting an image or text into multiple shares, such that when the shares are overlaid, the original image or text becomes visible.

Course Objectives:

- Learn about the internal representation of digital images
- Familiarize various image models and its usage
- Acquire the knowledge of digital image cryptography
- Learn the basic mathematics for secret sharing
- Attain the knowledge of encoding and decoding digital image for hiding useful information
- Familiarize the basic color image encryption and decryption algorithms

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Describe the fundamentals of image models, image representation and types of images
CO2	Illustrate the principles of steganography and digital watermarking and their applications
CO3	Explain various aspects of the real-world applications of Visual Cryptography
CO4	Explain various aspects of Color Visual Cryptography

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Digital image Processing: Fundamentals: Digital ImageRepresentation-coordinate conversions, images as matrices, Image Types - intensity images, binary images, RGB images; Color Image Processing:- , Colour Image Representation- RGB model, CMY model, CMYK model, HSI model. Image file formats. (20 hours)

Module 2: Principles of steganography and digital watermarking and their applications. Secret Sharing- Introduction, History of secret sharing, principle of secret splitting, phases of secret sharing, Access Structures, Threshold Schemes, Shamir's Scheme, Applications. (20 hours)

Module 3: Visual Cryptography- Introduction - History of Visual Cryptography, Construction of Visual Cryptography Schemes, basis matrices, Construction of 2-out-of-2 Visual Cryptography Schemes, Construction of 2-out-of-2 Visual Cryptography Schemes with Square Pixel Expansion, Construction of Visual Cryptography Schemes with Consistent Image Size. Visual Cryptography Schemes- Construction of 2-out-of-n Visual Cryptography Schemes, Basis

Matrices for 2-out-of-n Visual Cryptography Schemes, Construction of n-out-of-n Visual Cryptography Schemes, Basis Matrices for n-out-of-n Visual Cryptography Schemes, Construction of k-out-ofn Visual Cryptography Schemes, Basis Matrices for k-out-of-n Visual Cryptography.(20 hours)

Module 4: MColour Visual Cryptography – subpixel layout of colour visual cryptography, Variations of colour visual cryptography Schemes- Constructing a '2 out of 2' colour Visual Cryptography Schemes, Constructing a '2 out of n' colour Visual Cryptography Schemes, Applications of Visual Cryptography. (20 hours)

Module X

Visual Cryptography in the Frequency Domain, Secret Sharing Schemes with Visual Cryptography. Robust Watermarking Techniques. Steganography in Multimedia Data. Steganalysis Techniques.

Core Compulsory Readings

1. Borko Furht, Edin Muharemagic and Daniel Socek, Multimedia Encryption and Watermarking, Springer.
2. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson Education.
3. Jen- Shyang Pan, Hsiang- Cheh Huang and Lakhi C. Jain, Intelligent Watermarking Techniques, World Scientific.
4. Josef Pieprzyk, Thomas hardjino and Jennifer Sebberry, Fundamentals of computer security, Springer International Edition 2008

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Digital Learning.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Printed note

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

SAMPLE QUESTIONS

1. Describe the phases of secret sharing and the concept of access structures
2. What are the commonly used image file formats in digital image processing?
3. Explain the construction of 2-out-of-2 visual cryptography schemes.
4. Discuss the applications of color visual cryptography in various fields such as secure image sharing and authentication.
5. What is M-color visual cryptography? How does it differ from traditional visual cryptography?

KU10DSECSE510 SOFTWARE-DEFINED NETWORK

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE510	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course introduces software defined networking, an emerging paradigm in computer networking that allows a logically centralized software program to control the behavior of an entire network.

Course Objectives:

- Provide exposure to the various aspects of software defined networks

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Differentiate between traditional networks and software defined networks
CO2	Understand advanced and emerging networking technologies
CO3	Obtain skills to do advanced networking research and programming
CO4	Learn how to use software programs to perform varying and complex networking tasks

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: SDN: Origins and Evolution – Why SDN? - Centralized and Distributed Control and Data Planes. (20 hours)

Module 2: How SDN Works - The Openflow Protocol - SDN Controllers: Introduction - General Concepts - VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight. (20 hours)

Module 3: Network Programmability - Network Function Virtualization - NetApp Development. (20 hours)

Module 4: SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3. (20 hours)

Module X: The Genesis of SDN - Layer 3 Centric - Plexxi - Cisco OnePK - Network Slicing - SDN Open Source - Future of SDN (10 Hours)

Core Compulsory Readings

1. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014
2. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013
3. SiamakAzodolmolky, Software Defined Networking with OpenFlow, Packt Publishing, 2013
4. Feamster, Nick, Jennifer Rexford, and Ellen Zegura. "The road to SDN: an intellectual history of programmable networks." ACM SIGCOMM Computer Communication Review 44.2 (2014): 87-98
5. Kreutz, Diego, et al. Software-defined networking: A comprehensive survey, Proceedings of the IEEE 103.1 (2015): 14-76

6. Nunes, Bruno AA, et al. A survey of software-defined networking: Past, present, and future of programmable networks, Communications Surveys & Tutorials, IEEE 16.3 (2014): 1617-1634
7. Lantz, Bob, Brandon Heller, and Nick McKeown. A network in a laptop: rapid prototyping for software-defined networks, Proceedings of the 9th ACM SIGCOMM Workshop on Hot Topics in Networks. ACM, 2010
8. Monsanto, Christopher, et al. Composing software defined networks, 10th USENIX Symposium on Networked Systems Design and Implementation (NSDI 13). 2013

TEACHING LEARNING STRATEGIES

- Lecturing

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

Sample Questions

1. Explain the concept of SDN
2. Discuss the features of OpenFlow protocol
3. Explain about NetApp development
4. Prepare a short note of SDN in data center environment.

KU10DSECSE511 SPEECH, AUDIO AND VIDEO FORENSICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	DSE	500	KU10DSECSE511	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course examines the utilization of speech, linguistics, and media within forensic science, concentrating on the fundamentals of sound, analysis and synthesis of sound and speech, as well as electronic recording and transmission devices.

Course Objectives:

- Provide an overview of the field of forensic linguistics and its applications in legal and forensic contexts.
- Explore methods for analyzing speech patterns and vocal characteristics to determine speaker identity and authenticity.
- Study techniques for analyzing and authenticating digital media, including audio and video recordings, images, and text messages.
- Discuss the ethical and legal implications of utilizing speech, linguistics, audio, video and media in forensic science

Course Outcomes:

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the basic principles of voice and the physics involved in sound production
CO2	Identify and explain various audio and video technologies, playback devices, storage options, and preservation techniques
CO3	Recognize the significance of language-related evidence in court and distinguish the many linguistic data types that might be cited as proof
CO4	Utilize various strategies and approaches to identify and recognize speakers in forensic situations following the concept of test and error in speaker identification

Mapping of COs to PSOs

	PSO1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Physics of sound: waves and sound, analysis and synthesis of complex waves, Human and non-human utterances, anatomy of vocal tract, vocal formants, analysis of vocal sound, frequencies, and overtones.

Electronics of Audio Recording, Transmission and Playback devices, noise and distortion, voice storage and preservation. (20 hours)

Module 2: Forensic Linguistics: Phonetics, Morphology, Syntax, Semantics, Stylistics, Pragmatics, Script, orthography and graphology, Difference between language and speech, Psycholinguistics, Neurolinguistics, Sociolinguistics, Scientific approaches; Reliability and admissibility of evidence in the court, linguistic profile, language register. Discourse Analysis: Connivance, acceptance, listening feedback and rejection in the context of Mens-Rea, Narrative, Dialectology, Linguistic variety as a geographical marker, Idiolects and speaker characterization, Phonology, Morphology and Word formation processes as individual linguistic abilities. (20 hours)

Module 3: Various approaches in Forensic Speaker Identification, Instrumental Analysis of speech sample, Interpretation of result, Statistical interpretation of probability scale, Objective/Subjective methods, discriminating tests, closed test, open test, likelihood ratio calculation, Concept of test and error in Speaker Identification, case studies. Techniques and Best Practices for examination of Audio recording authentication and case studies. (20 hours)

Module 4: Audio /video forensics: Spectrography – Conversion of different voice file formats into forensic voice module formats. Various types of spectrograms, spectrographic cues for vowels and consonants. Speech analysis in forensic sciences. Speech synthesis by analysis, Speech recognition and speaker identification. Fundamentals of Digital Signal processing and communication system. Analogue and digital systems, Analogue signal and digital signals, Analogue to digital and digital to analogue converters, need and advantages of digital systems and digital signal processing. Forensic extraction of video files from DVR and other storage media. Forensic examination of DVR containing video footages, its frame analysis. Forensic examination and authentication of meta data present in video/audio files. Enhancement of video/Photo and its comparison/authentication.(20 hours)

Module X (Teacher Specific) : Multi speaker profiling- extraction of human body features from speech (10 hours)

Core Compulsory Readings

1. Bengold & Nelson Moryson, Speech and Audio signal processing, JohnWiley, Sons, USA(1999).
2. D.B.Fry, The Physics of Speech ,Cambridge University Press,(2004).
3. Dwight Bolingeret. al.; Aspects of Language, Third Edition, Harcourt Brace Jovanovich College Publishers, USA, (1981).
4. Gloria J.Borden et.al, Speech Science Primer (Physiology, Acoustics and Perception of Speech)",6thEd, a Wolters Kluwer Company, USA, (2011).
5. Harry Hollien, Forensic Voice Identification,Academic Press, London.(2001)
6. Harry Hollien, The Acoustics of Crime The New Science of Forensic Phonetics, Plenum Press, New York and London (1990).
7. Oscar Tosi, Voice Identification Theory of Legal Applications, University Park Press, Baltimore (1979).
8. Shaughnessy, Douglas, Speech Communication, ,Hyderabad Universities Press (India) Pvt. Ltd. (2001)
9. Patricia Ashby, Speech Sounds, 2ndEd, Routledge, London and NewYork (2005)
10. PhilipRose, Forensic Speaker Identification, Taylor and Francis , Forensic Science Series,London (2002)
11. SimonJ.Godsill, Digital Audio Restoration, Springer,(1998)

TEACHING LEARNING STRATEGIES

- Lecturing, Lab

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 2 Credit Theory + 2 Credit Practical.

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1

KU4SECCSE201 Python Programming

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU4SECCSE201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course mainly focuses on introducing the fundamental programming concept to the students from other disciplines. This course mainly focuses on the basic concept of programming constructs such as language elements, data types, operators control structures and data structure that will be useful for the programmers to learn the basic programming concept. Structure of this course is well organized to introduce the programing basic concept to advanced concepts such as modules, packages, GUI, and basics of NLP concepts for pattern matching and searching. After completing this course, the students acquire the ability to develop real life applications commonly useful for society in many walks of life.

Course Objectives:

- Aims to impart basic programming skills to the learners in a simplest way.
- Impart knowledge on fundamental and advanced data structure concepts.
- Acquire the knowledge to impart various control structures to implement programming logic.
- Aware about the development of common GUI based applications in simple steps.
- Acquire the ability to analysis of data using NumPy and Pandas

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Familiarize the different parts of Python programming and its applications in real world problems
CO2	Understanding the concept of different control structures and functions in Python.
CO3	Aware about the various data types and it operations and supporting methods
CO4	Make aware about the advanced concepts in Python such as reading and writing of data files, NumPy, Pandas and GUIs.

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction: History of Python Programming, Thrust Areas Of Python, Installing Anaconda Python Distribution, PyCharm IDE and Jupyter Notebook, Creating And Running First Python Project, **Parts of Python Programming Language**-identifiers, keywords, statements and expressions, variables, operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversion, The *typedef()* function and Is operator **(15 Hours)**

Module 2: Control Flow Statement- Decision control flow statement *(if, if …else, if…elif…,* nested *if*), Loop (*while, for*),*continue*, *break* statements, Catching Exception Using *try* and *except* Statement **Functions-** Built-In Functions Commonly used Modules, Function definition and calling the function, The *return* statement and *void* function, scope and life time of variables. **(15 Hours)**

Module 3: Lists- Creating List, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions used on lists, list Methods. **Dictionaries**- Creating Dictionary, Accessing and Modifying *key:value* Pairs in Dictionaries, Built-In Functions used on Dictionaries, Dictionary Methods. **Tuples and Sets-** Creating Tuples, Basic Tuple Operations, Indexing and Slicing in Tuples, Built-In Functions used on Tuples, Relation between Tuples and Lists, Sets and Set Methods, Frozenset. **Strings-** Creating and Storing Strings, Basic String Operations, Accessing

Characters in String by Index Number, String Slicing and Joining, String Methods, Formatting Strings **(15 Hours)**

Module 4: Files- Types of Files, Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary files, Reading and Writing CSV Files, Introduction to NumPy and Pandas.

GUIs in Python: Root Window-Fonts and colors- Working with containers and canvas, Frames, Widgets, Button widgets, Arranging widgets in the Frame, Label Widget, Message Widget, Text widget, Scrollbar widgets, Check button widget, Radio button widget, Entry Widget, Spin box Widget, List Box Widget, Menu Widget **(15 Hours)**

Core Compulsory Readings

1. Gowrishankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/Taylor & Francis, 2018. ISBN-13: 978-0815394372
2. Alberto Fernandez Villan, Mastering OpenCV 4 with Python, Packt Publishing Ltd.
3. Dr. R Nageswara Rao, Core Python Programming, 2nd edition, Dreamtech Publisher, 2019

Core Suggested Readings

1. Geron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 1st Edition, O'Reilly Media, 2017. ISBN – 13: 978-1491962299.

2. Wesley J. Chun, Core Python Programming, Second Edition, Publisher: Prentice Hall Pub

TEACHING LEARNING STRATEGIES

- Lecturing, case study/mini projects, Team Learning, presenting seminars on selected topics, Digital Learning

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Print.

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1. 1.What are the fundamentals of data types in Python?
2. 2.What are the different control structures in Python?
3. 3.Explain the function and syntax of for loop control structure in Python with example.
4. 4.What are functions? Explain how it differ from modules?
5. 5.Explain the differences between modules and packages.
6. What are the different string operations in python? Explain.
7. Differentiate between mutable and immutable objects in Python,
8. Explain the basic operations on List.
9. What are the different types of errors in a program? Explain each one.
10. What is a CSV file?
11. Explain how you will read CSV files in Python.
12. 12.What are Pandas? Explain its usage.
13. What are GUIs?
14. Explain the different Widgets in Python.
15. What is Canvas? Explain how it differs from Frames.

KU4SECCSE202 Fundamentals of Digital Skilling using Google Workspace for Education

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU4SECCSE202	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course is intended to provide a fundamental understanding about the services offered by the Google Workspace for Education. Learners will get an exposure to how to use the services such as Google Drive, Google Docs, Google Sheet and Google Slides for their personal and collaborative learning strategies.

Course Objectives:

- To familiarize with about the Google Workspace for Education
- To understand the fundamentals of Gmail
- To get familiar with Google Drive
- To create documents using Google Doc and Google Sheet
- To create slides using Google Slides

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Identify the services offered by Google Workspace for Education and get exposed to the fundamentals of Gmail
CO2	Illustrate the foundations of preparing documents using Google Docs
CO3	Prepare documents using Google Sheets
CO4	Prepare slides using Google Slides

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Google Workplace for Education: Gmail, Google Calendar, Google Drive, Google Docs, Google Sheets, Google Slides. Gmail - Creation of ID - Composing Messages - Folders - Labels - Simple Customizations. **(15 Hours)**

Module 2:. Google Drive: Uses - Accessing - Viewing Drive Contents - Creating Folders - Creating Documents - Making Copies - Uploading Documents - Downloading Folder Contents - Sharing Folders - Erasing Documents - Creating and Managing Workspaces - Searching Contents - Managing Storage. **(15 Hours)**

Module 3: Google Doc: Creation - Saving - Typesetting and Formatting - Images - Tables - Charts - Line - Emoji - Smart Chips - Dropdown - Footnote - Header and Footer - Page Numbers - Indentation - Lists - Checklists - Creating Links - Watermark - Page Orientation - Spelling and Grammar Check - Citations - Modes (View / Review / Edit) - Voice Typing - Print - Download - Sharing. **(15 Hours)**

Module 4: Google Sheet: Creation - Components - Cells and Addressing - Navigating. Entering and Editing Data: Text - Equations - Typesetting and Formatting. Saving Worksheet. Editing Worksheet Data - Moving and copying data - Moving and copying equations - Inserting and deleting ranges, rows, and columns. Formatting: Text - Numbers - Row and Column -- Conditional Format - Borders and Colors. Worksheets: Naming, Copying, Creating, Removing Charts: Types - Pie Chart - Bar Chart. Data - Sorting - Filters - Validation - Removal of Duplicates. - Page Orientation - Spelling and Grammar Check - Print - Download - Sharing. **(10 Hours)**

Module X (Teacher Specific): Google Slide: - Creating Slides - Adding Image, Text Box, Audio, Video, Shape, Chart, Diagram. Typesetting and Formatting - Lists - Checkboxes. Slides: Ordering - Changing Background - Deleting - Transition. Share - Print – Download **(5 Hours)**

Core Compulsory Readings

1. Learn the basics, https://workspace.google.com/intl/en_in/training/

Core Suggested Readings

1.Online materials related to Google Workplace for Education.

2 Digital Skilling Course (NPTEL),

https://drive.google.com/file/d/1eKZP5LchZqrf3Ba9MjjeMDUh7cjbDOR9/view?usp=sharing

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Notes

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Semester 5 SEC POOL 2

KU5SECCSE203 The Art of E - Documentation using Latex

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU5SECCSE203	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course is intended to impart the foundations of document preparation using Latex. Latex is a simple but flexible and powerful document editor that can be used to create documents of varying purposes. It can also be used to create slides for presentations.

Course Objectives:

- To impart knowledge about the structure of Latex documents
- To become familiar with using the various options to type set and format contents in Latex
- To create documents with tables, list and images in Latex
- To add citations and references for a scientific document

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Identify the anatomy of a Latex document and prepare simple documents in Latex
CO2	Illustrate the foundations of typesetting and formatting in Latex
CO3	Prepare documents with lists, tables and images and to create references and citations
CO4	Create slides using beamer

COURSE CONTENTS

Module 1: WYSIWYG Editors Vs Latex. Latex: History - Advantages - Editors (Windows / Mac / Ubuntu - Online). Anatomy of Latex Document - Common Document Classes - Paper sizes - Commonly Used Packages - Setting margins. Document Creation - Beginning Document - Sections - Adding Text - Inserting blank lines - Ending Document **(15 Hours)**

Module 2: Typesetting Document - Fonts, symbols, indenting, paragraphs, line spacing, word spacing, titles and subtitles, adding colors to text and entire page, adding bullets and numbered items. Adding header and footer, changing the page orientation, dividing the document into multiple columns **(15 Hours)**

Module 3: Creating Tables: Setting Columns - Merging Rows and Columns - Various Styles and Orientation. Adding Images - Graphics Packages - Rotation - Scaling. Drawing Matrices - Adding Mathematical Symbols and Equations. Adding Bibliography, Cross References and Citations - Adding Table of Contents, Figures and Tables **(15 Hours)**

Module 4: Beamer - Creating Slides - Adding frames - Dividing the slide into multiple columns - Adding different blocks - Adding Tables and Graphics. Case Study: Preparation of Resume, Official Letters, Book, Article, Homework assignment **(15 Hours)**

Core Compulsory Readings

1. Free online introduction to LaTeX Available at https://www.overleaf.com/learn/latex/Free_online_introduction_to_LaTeX_(part_1)
2. Learning Latex, D.F.Griffits, D.J.Higham, Siam, Philadelpha, 1997
3. Latex, https://en.wikibooks.org/wiki/LaTeX

Core Suggested Readings

1.Online materials related to document preparation using Latex and slide preparation using Beamer

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Notes

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

KU5SECCSE204 Data Processing with Python

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU5SECCSE204	3	60

Learning Approach (Hours/ Week)	Marks Distribution	

Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	Duration of ESE (Hours)
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course includes an overview of the various tools available for writing codes and running the same in Python, and gets students coding quickly. It also provides hands-on coding exercises using commonly used data structures and writing custom functions after preprocessing the dataset.

Course Objectives:

- Understand how to perform some basic tasks to start exploring and analyzing the imported data set
- Learn how to perform computations on the data to calculate basic descriptive statistical information
- Learn how to manipulate data efficiently.
- Understand the visualization and analytics of data.

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	To understand python fundamentals and data types used in python
CO2	To learn basic statistical measurements required for machine learning
CO3	To familiarize preprocessing of data before processing.
CO4	To experience visualization of 1D and 2D data

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Python Fundamentals: Basic Concepts, Naming Variables, Operators and operands, Expressions, importing libraries, Redirecting the output, Data types, Lists, Working with files, Working with Directories; Big Data vs Data Science **(15 Hours)**

Module 2: Introduction to probability: discrete and continuous variables, probability distribution, Bayes Rule, Variance, Standard Deviation, Types of probability distributions, Algorithms designed using probability, **(15 Hours)**

Module 3: Finding datasets, Jupiter notebooks and loading data, pandas vs numpy, Saving, Dropping Null Values, User Defined Functions, Cleaning Dataset, Graphs and Statistics, Histogram, Working with rows and columns. **(15 Hours)**

Module 4: Introduction to basic plots, pandas vs matplotlib, visualizing 1D distributions, visualizing 2D distributions, Higher dimension visualizations. **(15 Hours)**

Core Compulsory Readings

1. Wes McKinney, "Python for Data Analysis", 2nd Edition, O'Reilly
2. Joel Grus," Data Science from Scratch" First Edition, April 2015

3. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.".

TEACHING LEARNING STRATEGIES

Lecturing, case study/mini projects, Team Learning, presenting seminars on selected topics, Digital Learning

MODE OF TRANSACTION

Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Print.

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1. What skills are necessary for a Data Scientist?
2. Statistics
3. Deep Learning
4. Linear Algebra
5. All of the above
6. CLI stands for ………..
7. Command Line Interface
8. Command Language Interface
9. Command Line intercom
10. None of the Above

11. Give one example where both false positives and false negatives are important equally?
12. Write the difference between data analytics and data science.
13. What are data science tools?
14. List different data types available in python with examples for each.

KU5SECCSE205 - Data Science Fundamentals

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU5SECCSE205	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: A Data Science course covers basic and advanced concepts of data analytics, machine learning, statistics, and programming languages like Python or R. It also teaches students how to clean a dataset, and interpret large datasets and identify patterns to create predictive models.

Course Objectives:

- To provide a strong foundation for data science and application area related to it and understand the underlying core concepts and emerging technologies in data science.
- Demonstrate an understanding of statistics and machine learning concepts that are vital for data science
- Explain how data is collected, managed and stored for data science
- To understand how to perform data analysis and visualization tasks.

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	To learn basic ideas about data science fundamentals, machine learning and statistical probabilities.
CO2	To understand different types of data such as structured and unstructured data.
CO3	To familiarize different classification algorithms.
CO4	To experiment different algorithms using python and calculate the accuracy.

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Data Science: Definition, Big data, populations and samples, exploratory data analysis, properties of data, Mathematical and Statistical Skills, Data Analysis Tools, Data Science Applications **(15 Hours)**

Module 2: Types of data, Application areas of Data Science, Data Science process, Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Introduction to Statistics. **(15 Hours)**

Module 3: Basic Machine Learning Algorithms: Linear Regression, SVM, Naïve Bayes, example program implementation, Data acquisition, Transformation into standardized format, Data Cleaning, Data Reduction, Data Integration, Data Transformation, Normalization. **(15 Hours)**

Module 4: Algorithm design and analysis, Data, Database Table, Python, Confusion Matrix, Data Handling and Visualization, Different Chart types, Plotting Functions, Solving problem with Data Science. **(15 Hours)**

Core Compulsory Readings

Text Book

1. Rachel Schutt &O'neil, "Doing Data Science", Straight Talk from The Frontline O'REILLY, ISBN:978-1-449-35865-5, 1st edition, October 2013.
2. Joel Grus," Data Science from Scratch" First Edition, April 2015

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration

MODE OF TRANSACTION

- Lecture, Seminar, Discussion, Notes

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1. Identify the language which is used in data science.

a. R

b. C++

c. Java

d. Ruby

2. Total groups in which data can be characterized is:

a) 4

b) 2

c) 1

d) 3

3. What are some of the techniques used for sampling?
4. Explain the major Components of Data Science.
5. What is Data Science? List the differences between supervised and unsupervised learning.
6. List some of the applications of data science in the real-world scenario.
7. Write the difference between a box plot and a histogram.

Semester 6 SEC POOL 3

KU6SECCSE301 Artificial Intelligence and Daily Life

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	300	KU6SECCSE301	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: The objective of the course is to communicate the fundamental knowledge in the specialized area of Artificial Intelligence. The program focuses on building a comprehensive understanding on the basics of Artificial Intelligence and interact with inter- disciplinary groups.

Course Objectives:

- To understand the history of artificial intelligence (AI) and its foundations
- To understand the basic principles of AI for solving daily life problems

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Acquire knowledge about Artificial Intelligence
CO2	Obtain knowledge about Search and Control Strategies
CO3	Attain information about the fundamentals of Machine Learning
CO4	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, Natural language Processing- machine learning models.

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Artificial Intelligence- History of AI- Advantages and Disadvantages of AI- Applications- AI domains.AI in real life, Expert system - Expert system development- Modern expert systems **(15 Hours)**

Module 2: Search and Control Strategies- State- Space representation- Problem Solving - Heuristic Techniques – Hill Climbing – Simulated Annealing **(15 Hours)**

Module 3: Machine Learning- Supervised and Unsupervised Algorithms- Neural Networks- Classification and Predictions model – Applications **(15 Hours)**

Module 4: Natural Language Processing - Natural Language Processing Tasks - NLP Applications- Recommender System - Sentimental Analysis **(15 Hours)**

Core Compulsory Readings

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach Third Edition Pearson Education 2010 Inc. ISBN: 978-0-13-604259-5.

2. D W Patterson, introduction to Artificial Intelligence and Expert Systems, PHI, 1990.

Core Suggested Readings

1. E. Rich, K. Knight, S B Nair, Artificial intelligence, 3rdEdn, McGraw Hill.

2.https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_overview.html

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab
- , Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

KU6SECCSE302 Fundamentals of Big Data

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	300	KU6SECCSE302	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description: This course mainly focuses to introduce the fundamentals of big data analytics concept using Python programming language. First part of this course familiarizes basic concepts of the python programming language and subsequently introduces the big data analytics concepts and machine learning algorithms for developing mathematical/statistical models for analyzing big data using NumPy and Pandas in Python. After completing this course, the students acquire the basic ability to develop real life applications for extracting hidden patterns/trends in a big data environment that is commonly useful for society in many walks of life.

Course Objectives:

- Aims to impart basic programming skills to the learners for developing mathematical models for big data analysis.
- Impart knowledge on fundamental and advanced data structure concepts in Python programming language suitable for big data analysis.
- Aim to impart to knowledge in bigdata platforms and developing mathematical/statistical models for big data analysis using machine learning concepts.
- Acquire the ability to analysis of data using NumPy and Pandas

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Familiarize the different parts of Python programming and its applications in real world problems
CO2	Understanding the concept of different control structures and functions in Python.
CO3	Aware about the different types of data files and an overview of various data analytics methods.
CO4	Acquire the knowledge of different machine learning algorithms and its implementation for building efficient data analytics models for real life.

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: History of Python Programming, Thrust Areas Of Python, Installing Anaconda Python Distribution, PyCharm IDE and Jupyter Notebook, Creating And Running First Python Project, **Parts of Python Programming Language**-identifiers, keywords, statements and expressions, variables, operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversion, The *typedef()* function and Is operator, **(15 Hours)**

Module 2: Control Flow Statement- Decision control flow statement *(if, if …else, if…elif…*, nested *if*), Loop (*while, for*),*continue*, *break* statements, Catching Exception Using *try* and *except* Statement **Functions-** Built-In Functions, commonly used Modules, Function definition and calling the function, The *return* statement and *void* function, scope and life time of variables **(15 Hours)**

Module 3: Files: - Types of Files: -Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary files, Reading and Writing CSV Files, Introduction to NumPy and Pandas.

Data Analytics Overview - Statistical Computing - Mathematical Computing Using NumPy - Data Processing with Pandas - Data Visualization with Python - Introduction to Model Building for Evaluation **(15 Hours)**

Module 4: Supervised Learning - Classification, Naive Bayes, KNN, Linear Regression. Unsupervised Learning - Clustering, Hierarchical algorithms – Agglomerative algorithm, Partitional algorithms -K- Means. Association Rule Mining - Apriori algorithm. **(15 Hours)**

Core Compulsory Readings

1. Bart Baesens," Analytics in a Big Data World: The Essential Guide to Data Science and its Business Intelligence and Analytic Trends", John Wiley & Sons, 2013.

2. David Dietrich, "EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", John Wiley & Sons, 2015.

3.Dr. R Nageswara Rao, Core Python Programming, 2nd edition, Dreamtech Publisher, 2019

TEACHING LEARNING STRATEGIES

Lecturing, case study/mini projects, Team Learning, presenting seminars on selected topics, Digital Learning

MODE OF TRANSACTION

Lecture, Seminar, Discussion, Demonstration, Questioning and Answering, Audio, Video, Print.

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1.What are the fundamentals data types in Python?

2.What are the different control structures in Python?

3.Explain the function and syntax of for loop control structure in Python with example.

4.What are functions? Explain how it differ from modules?

5.Explain the differences between modules and packages.

6. What are the different string operations in python? Explain.

7. What is CSV file?

8. Explain how will you read CSV files in Python.

9.What are Pandas? Explain its usage.

10. What is NumPy?

11. Explain the use of pandas in big data analytics.

12.What is Big Data?

13. What are the different tools in Python for data visualization? Explain.

14. What is KNN?

15. Explain about supervised and unsupervised learning with suitable examples.

KU6SECCSE303 Optimization Techniques

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	300	KU6SECCSE303	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

Optimization, also known as mathematical programming, collection of mathematical principles and methods used for solving quantitative problems in various disciplines, including physics, biology, engineering, economics, and business. The subject grew from a insight that quantitative problems in obviously different disciplines have important mathematical elements in common.

Course Objectives:

- To understand the need of optimization
- To study various optimization techniques

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Understand the importance of optimization technique
CO2	Discuss Optimum design concepts
CO3	Solve the Linear Programming models using graphical and simplex methods
CO4	Evaluate different algorithmic methods for solving constrained and unconstrained optimization problems

Mapping of COs to PSOs

CO - PSO Mapping					
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1:

Optimization: Introduction, Statement of an Optimization problem,formulation of Optimal Problem, Types of Optimization problem. **(15 Hours)**

Module 2:

Optimum design concepts: Definition of Global and Local optima,Optimality criteria, Convexity and concavity of functions of one and two variables,Lagrangian function, Hessian matrix formulation **(15 Hours)**

Module 3:

Linear programming: Standard form of Linear Programming Problem,Canonical form, Elementary operations, Graphical method for two variable optimization problem, Simplex method, Karmarkar's projective scaling method. **(15 Hours)**

Module 4:

Optimization algorithms for solving unconstrained optimizationproblems – Gradient based method: Cauchy's steepest descent method, Newton'smethod, Conjugate gradient method. Optimization algorithms for solving constrained optimization problems– direct methods – penalty function methods – steepest descent method. **(15 Hours)**

Core Compulsory Readings

1. G. Hadley, Linear programming, Narosa Publishing House, New Delhi, ISBN

13: 9788185015910.

2. Singiresu S. Rao, Engineering Optimization: Theory and Practice by John Wiley and Sons, (5th edition),ISBN: 978-1-119-55479-3

Core Suggested Readings

1. Shikare MM, Waphare BN, Combinatorial Optimization, Narosa Publication (2004)

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration

MODE OF TRANSACTION

Lecture, Seminar, Discussion, Notes

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

KU6SECCSE304 WEB TECHNOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	300	KU6SECCSE304	3	60

Learning Approach (Hours/ Week)				Marks Distribution		Duration of ESE (Hours)
Lecture	Practical / Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P) *

*** ESE Duration: 2 hours for theory and 3 hours for Lab**

Course Description:

This course provides a comprehensive introduction to web technologies, covering both frontend and backend development concepts. Students will gain practical skills in building dynamic and responsive web applications while learning about the fundamental principles of web design, development, and deployment.

Course Objectives:

- Understand the structure and functionality of the internet and the World Wide Web.
- Differentiate between client-side and server-side technologies and understand their respective roles in web development.
- Gain an introduction to server-side programming languages such as PHP, Python, or Node.js.
- Gain an overview of web hosting options and deployment strategies for deploying web applications.
- Build a simple web project from scratch using frontend and backend technologies learned in previous modules.

Course Outcomes:

SL #	Course Outcomes
CO1	Create basic web pages using HTML and CSS.
CO2	Demonstrate proficiency in JavaScript programming
CO3	Understand the concepts of database management systems (DBMS) and SQL for managing data in web applications.
CO4	Students will be able to build a simple web project

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1			✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Module 1: Introduction to Web Technologies: Overview of the Internet and the World Wide Web. Client-side vs. server-side technologies. Basic concepts of HTML (Hypertext Markup Language) and CSS (Cascading Style Sheets), Introduction to web browsers and their developer tools, Building and viewing a simple webpage using HTML and CSS. (15 Hours)

Module 2: Advanced HTML5 features: Semantic elements, forms, and multimedia, Advanced CSS3 techniques: Flexbox, Grid layout, transitions, and animations, Introduction to responsive web design principles and techniques. Basics of JavaScript programming: Variables, data types, operators, and control structures. DOM manipulation using JavaScript: Selecting elements, modifying content, and handling events. Introduction to popular frontend frameworks/libraries such as Bootstrap and jQuery (15 Hours)

Module 3: Introduction to server-side programming languages: PHP, Python, or Node.js. Basics of database management systems (DBMS) and SQL (Structured Query Language). Building dynamic web applications with server-side scripting. Handling form data and user input in web applications. Introduction to RESTful APIs and AJAX for asynchronous communication (10 Hours)

Module 4: Basics of web performance optimization and debugging techniques. Introduction to web security best practices: HTTPS, CORS, XSS, CSRF. Overview of web hosting options and deployment strategies. Building a simple web project from scratch using frontend and backend technologies learned in previous modules. (15 Hours)

Module X (Teacher Specific): Responsive Web Design Frameworks, JavaScript Frameworks, Advanced Node.js Features, Web Server Frameworks, Advanced DOM Manipulation. Content Managements Systems (CMS) (5 Hours)

Core Compulsory Readings

1. Jeffrey C. Jackson, Web Technologies: A Computer Science Perspective, Prentice Hall
2. David Flanagan, JavaScript: The Definitive Guide, 6th Edn. O'Reilly Media.2011
3. Steven Holzner, PHP: The Complete Reference, McGraw Hill Professional, 2008
4. Steve Suehring, Tim Converse, Joyce Park, PHP6 and MY SQL Bible, John Wiley & Sons, 2009
5. Anthony T. HoldenerIII, Ajax: The Definitive Guide, O'Reilly Media, 2008

Core Suggested Readings

1. Bob Breedlove, et al, Web Programming Unleashed, Sams Net Publishing, 1stEdn
2. Pedro Teixeira, Instant Node.js Starter, Packt Publishing Ltd., 2013
3. James Snell, Programming Web Services with SOAP, O'Reilly 2002 10. Jacob Lett, Bootstrap Reference Guide, Bootstrap Creative 2018
4. Maximilian Schwarzmüller, Progressive Web Apps (PWA) - The Complete Guide, Packt Publishing 2018
5. Mahesh Panhale, Beginning Hybrid Mobile Application Development, Apress 2016

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning, Lab session

MODE OF TRANSACTION

- Lecture and Lab
- , Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes.

1. Explain the concept of client-side and server-side technologies in web development.
2. Describe the basic structure and purpose of HTML and CSS.
3. What are semantic elements in HTML5? Provide examples and explain their significance.
4. Compare PHP, Python, and Node.js as server-side programming languages. What are their strengths and weaknesses?
5. Explain the role of a database management system (DBMS) and SQL in web development.

MULTI DISCIPLINARY COURSES

Semester 1 MDC POOL 2

KU1MDCCSE101 Foundations of Information and Communication Technology

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU1MDCCSE101	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	0	50	50	100	2(T)+3(P)*

*** ESE Duration : 2 hours for theory and 3 hours for Lab**

Course Description:

This course helps the learners to understand the basic concepts on information and communication technology. The course briefs various technological artifacts of ICT, which includes the basic concepts on hardware and software perspectives, communication perspectives, storage technologies and recent trends in IT.

Course Objectives:

- Understand the Basic concepts of Computer hardware and different types of software.

- Familiarize with various digital communication technologies
- Understand various digital storage technologies
- Know recent technological trends in Information Technology and its applications in daily life

Course Outcome

At the end of the Course, the Student will be able to:

SL #	Course Outcomes
CO1	Familiarize the architecture of modern computer
CO2	Explain the functional units of operating system .
CO3	Illustrate the basic concepts of Computer networks
CO4	Familiarize with the various digital storage technologies
CO 5	Understand the recent trends in Information

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1

Computer – Hardware Perspectives : Basic Architecture of computers- Processor- Memory- Communication – Storage. Operating System : Basic concepts- Different types- Functional components of Operating system (Processing management unit- Memory management unit- Input/Output unit- Network and Communication Management- File and Secondary storage management). Different types of software (System software, Application software). (10 hours)

Module 2

Communication : Fundamentals of Computer Network-LAN, WAN, MAN, topology, networking devices. Protocols (OSI 7 Layer TCP/IP) - IP address (Classes)- Versions (IPV4 and IPV6)-Internet - WWW, URL, Domain names, Internet Services and Service Providers, Wireless Communication – Generations (1g, 2g,3g,4g,5g,6g) – Satellite Communication. (15 hours)

Module 3

Storage Technologies : - Secondary Storage – evolutions – Magnetic storage – Optical storage device – solid state storage device- RAID Technologies- Cloud storage- Data Centres – Storage area Network – Network attached Storage (15 hours)

Module 4

Recent Trends in Information Technology : Internet of things (IoT) – Bigdata and Data Science- Machine Learning- Artificial Intelligence – Application of AI and Machine Learning – AI Problems. (15 hours)

Module X (Teacher Specific module): Evolutionary computing- Nature Inspired computing- quantum computing – cyber security and Cyber Laws (10 hours)

Core Compulsory Readings

1. "Operating System Concepts" by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne.
2. "Operating System Design and Implementation" by Andrew S. Tanenbaum and Albert S. Woodhull.
3. V Rajaraman, Neeharika Adabala, Fundamentals of computers, 6th edition, PHI.
4. Pradeep K Sinha and Priti Sinha, Computer Fundamentals.
5. "Computer Networks" by Andrew S. Tanenbaum and David J. Wetherall.
6. "Computer Networking: A Top-Down Approach" by James F. Kurose and Keith W. Ross.
7. "Storage Networking Fundamentals: An Introduction to Storage Devices, Subsystems, Applications, Management, and File Systems" by Marc Farley.
8. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood.
9. "Internet of Things from Hype to Reality: The Road to Digitization Book" by Ammar Rayes and Samer Salam.
10. "Introduction to Machine Learning Book" by Ethem Alpaydın.
11. "Cyber Security and Cyber Laws" by Nilakshi Jain , Ramesh Menon.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

Sample Questions to test Outcomes

1. Explain various components of computers
2. What is operating system
3. Explain different types of network topologies
4. What is IP address
5. Explain Artificial Intelligence

STATISTICS/BIOSTATISTICS

COURSE DETAILS

STATISTICS/ BIOSTATISTICS

COURSE DETAILS

Semester I

A1 – DISCIPLINE SPECIFIC CORE COURSE

KU1DSCSTA101: DESCRIPTIVE STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	CORE	100	KU1DSCSTA101	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course serves as an introduction to statistical methods, covering key concepts and techniques essential for understanding and analyzing data. Through a combination of theoretical concepts and practical applications, students will learn key statistical techniques and methodologies for summarizing and interpreting data. The course is divided into four units, each focusing on different aspects of statistical analysis.

COURSE OBJECTIVES:

- Understand the fundamental concepts of statistics: Students will grasp the basic principles and terminology of statistics, including the definition and scope of the field.
- Recognize and classify types of data: Students will be able to identify and categorize different types of data, including quantitative and qualitative data, and understand the scales of measurement (nominal, ordinal, interval, and ratio).
- Utilize various data presentation techniques: Students will learn to present data effectively using tabular and graphical methods, including histograms, frequency polygons, bar charts, pie diagrams, stem and leaf charts, and ogives.
- Understand the concepts of central tendency, dispersion, skewness and kurtosis and their measures.

COURSE OUTCOMES

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Concepts of statistical population and sample, types of variables and attributes.
CO2	Tabular and graphical representation of data based on variables.
CO3	Measures of central tendency, dispersion and their computations.
CO4	Moments, skewness and kurtosis and their uses.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

UNIT 1

Statistical methods: - definition and scope of statistics, concepts of statistical population and sample, Data: - quantitative and qualitative, attributes, variables, scales of measurement nominal - ordinal, interval and ratio. Presentation: - tabular and graphical, including histogram, frequency polygon, Bar chart, Pie diagram, stem and leaf chart and ogives. **(15 Hours)**

UNIT 2

Measures of Central Tendency (Mathematical and positional averages) and their properties: Mean, median, mode, harmonic mean, geometric mean, weighted mean, quartiles, deciles, percentiles. Short-cut method for the evaluation of mean of raw and grouped data. **(20 Hours)**

UNIT 3

Measures of Dispersion :- Range, quartile deviation, mean deviation, standard deviation and variance. Relative and absolute measures of dispersion, coefficients of dispersion based on: - Range, quartile deviation, mean deviation, standard deviation;. Short-cut method for the evaluation of variance and standard deviation for raw and grouped data. Boxplot and Lorenze curve. **(20 Hours)**

UNIT 4

Measures of skewness and kurtosis: Moments, raw moments, central moments, relation between raw moments and central moments, absolute moments. Short-cut method for the evaluation of central moments of raw and grouped data, various measures of skewness and kurtosis. **(20 Hours)**

UNIT 5 (Teacher Specific Module- Optional)

History of Statistics, data entering using EXCEL/SPSS, understanding the usage of various statistical and mathematical functions in EXCEL/SPSS. Preparation of a questionnaire, data collection (online/offline) and analysis of data using methods explained in Units 1 to 4, preparation and submission of a report. **(15 Hours)**

TEXT BOOKS

1. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.
2. Dabas, P. (2024). ***Descriptive and Inferential Statistics Using R***. Sultan Chand and Sons' Publishers, New Delhi.
3. Mood, A.M., Graybill, F.A. and Bose, D.C. (2007). ***Introduction to the Theory of Statistics, 3rd Edn.***, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

SUGGESTED READINGS:

1. Spiegel, M. R. and Stephens, L. J. (2017). ***Schaum's Outline of Statistics***, 6th Edn., McGraw-Hill Education.
2. Gun, A. M., Gupta, M.K. and Dasgupta, B. (2008). ***Fundamentals of Statistics.*** India: World Press.
3. Armitage, P., Berry, G., and Matthews, J. N. S. (2008). ***Statistical Methods in Medical Research***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct class room Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester II

A2– DISCIPLINE SPECIFIC CORE COURSE

KU2DSCSTA102: FIRST COURSE ON THEORY OF PROBABILITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU2DSCSTA102	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to probability theory, covering foundational concepts, axiomatic definitions, conditional probability, independence, and the practical applications of Bayes' theorem. The course is structured into four units, each focusing on different aspects of probability theory.

COURSE OBJECTIVES:

- To develop a solid understanding of the fundamental concepts of probability theory, including random experiments, sample space, events, and basic probability calculations.
- To acquire knowledge of different definitions of probability, including classical, empirical, and axiomatic definitions, and understand the properties and limitations of each.
- To develop proficiency in applying mathematical concepts such as sets, sigma algebras, and measures to describe probability spaces and analyze probabilities of events.
- To enhance problem-solving skills by applying probability concepts to a variety of

real-world scenarios and numerical problems, including conditional probability, independence, and Bayes' theorem.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Understand Probability Foundations: Students will demonstrate a solid understanding of the foundational concepts of probability theory, including random experiments, sample space, events, and the distinction between mutually exclusive and exhaustive events.
CO2	Apply Axiomatic Definition of Probability: Upon completion of the course, students will be able to apply the axiomatic definition of probability, understanding probability as a measure and its representation in a probability space.
CO3	Analyze Conditional Probability and Independence: Students will demonstrate proficiency in calculating conditional and marginal probabilities, as well as joint probabilities.
CO4	Apply Bayes' Theorem in Practical Situations: By the end of the course, students will be able to apply Bayes' theorem to solve practical problems involving conditional probability and independence.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

UNIT 1

Elementary Probability Theory: Random experiment, sample space and events, mutually exclusive and exhaustive events, partition of sample space, empirical and classical definitions of probabilities and properties, examples using classical definition of probability, merits and limitations of classical and empirical definitions. **(15 hrs)**

UNIT 2

Axiomatic Definition of Probability: Class of sets, sigma algebra of events, axiomatic definition of probability, probability as a measure, probability space, basic theorems in probability using axioms, advantageous of axiomatic definition of probability, addition theorem (for two and three events), generalization of addition theorem (without proof). Boole's inequality.
(**20 Hours)**

UNIT 3

Conditional Probability and Independence: Conditional and marginal probabilities, joint probability, independence of events, pairwise and mutual independence and their implications, examples. Multiplication theorem for two and three events, generalization of multiplication theorem for n-events (without proof), numerical illustrations**.**
(20 Hours)

UNIT 4

Bayes' Theorem and Applications: Total probability, Bayes' theorem, prior and posterior probabilities, Monty Hall problem, solution to various problems related to Bayes' theorem, numerical illustrations. **(15 Hours)**

UNIT 5 (Teacher Specific Module- Optional)

Prerequisites to Study Probability Theory: History of probability, paradoxes in probability, basic set theory for probability, representation of sets in Venn diagram, operations of sets- union, intersection, complementation, basic principle of counting, problems related to permutation and combination. Computations using R. **(20 Hours)**

TEXT BOOKS

1. Ross, S. (2010). ***A First Course in Probability***. 8th Ed., Pearson, Prentice Hall.
2. Spiegel, M. R., Schiller, J. J., and Srinivasan, R. A. (2013). ***Schaum's outline of Probability and Statistics***. McGraw-Hill Education**.**

SUGGESTED READINGS

1. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.
2. Gut, A. (2005). ***Probability: A Graduate Course***. Springer, New York.
3. Baclawski, K. (2008). ***Introduction to Probability with R***. Chapman and Hall/CRC.
4. Feller, W. (1999). ***An Introduction to Probability Theory and Its Applications*** **(Vol. 1)**. Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester II

A3– DISCIPLINE SPECIFIC CORE COURSE

KU2DSCSTA103: INTRODUCTION TO R PROGRAMMING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU2DSCSTA103	4	90

Learning Approach (Hours/ Week)	Marks Distribution	Duration of

Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	ESE (Hours)
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course serves as an introduction to R programming, a powerful tool widely used for data analysis and statistical computing. Through a series of hands-on exercises and practical examples, students will learn how to use R for data manipulation, visualization, and statistical analysis.

COURSE OBJECTIVES:

- Understand the installation process of R and its basic functionalities.
- Familiarize with R preliminaries, including objects, classes, operators, and common built-in functions.
- Learn to install new packages and explore different datasets available in R packages for analysis.
- Explore graphical representations of data using R, such as histograms, bar plots, box plots, stem-and-leaf plots, scatter plots, and Q-Q plots.
- Learn to write custom functions in R for specific statistical analyses and implement them in simple R programs.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Demonstrate proficiency in the fundamentals of R programming, including installing R, using R as a calculator, understanding R preliminaries.
CO2	Learners will develop a solid understanding of various data structures in R such as vectors, lists, matrices, and data frames.
CO3	Students will apply R programming skills to perform descriptive statistical analysis, including calculating measures of central tendency, dispersion, skewness, and kurtosis.

CO4	Proficiency in Writing R Programs for Data Analysis: Students will develop the ability to write R programs for statistical analysis, including looping structures (for, repeat, while), conditional statements (if, if-else), and custom function creation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to R- Installation of R, R as a calculator, R preliminaries, objects and their classes, operators, methods of data input, importing and exporting data. Getting help, saving, storing and retrieving work, common built-in functions. **(15 Hours)**

UNIT 2

Data structure of R: Vectors, lists, matrices, arrays, factors, data frames, strings. Indexing and accessing data,**,** installation of new packages, different data sets available in R package **(20 Hours)**

UNIT 3

Simple Applications – Descriptive statistics: Measures of central tendency, measures of dispersion, skewness and kurtosis, R-Graphics- histogram, bar plot, Box-plot, stem and leaf plot, scatter plot, Q-Q plot, matrix operations: addition, multiplication, inverse, power, determinant, eigenvalue, eigenvector, solution of system of linear equations. (**20 Hours)**

UNIT 4

Writing R Programmes- Looping- For loop, repeat loop, while loop, if command, if else command, in-built functions and custom functions in R. Writing simple programmes in R for statistical analysis. (**15 Hours**)

UNIT 5 (Teacher Specific Module- Optional)

Introduction to R-Studio and R Markdown. Practicals using R to obtain graphical representation of data, summarization of data and tabulated form of data. (**20 Hours)**

TEXT BOOKS

1. Maria D.U., Ana F.M. and Alan T.A. (2008*):* ***Probability and Statistics with R.*** CRC Press.
2. Dalgaard, P. (2008): ***Introductory Statistics with R (Second Edition)****,* Springer.

SUGGESTED READINGS

1. Purohit, S.G., Gore, S. D. and Deshmukh, S. R. (2004): ***Statistics Using R***. Narosa.
2. Maria L. Rizzo (2019). ***Statistical Computing with R***, ***Second Edition.*** Chapman & Hall, CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester III

A4– DISCIPLINE SPECIFIC CORE COURSE

KU3DSCSTA201: THEORY OF RANDOM VARIABLES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCSTA201	4	90

Learning Approach (Hours/ Week)	Marks Distribution	Duration of

Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	ESE (Hours)
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive understanding of probability theory and random variables, covering both discrete and continuous probability distributions, as well as joint distributions and mathematical expectations. Through a series of lectures, discussions, and practical exercises, students will gain the necessary knowledge and skills to analyze and interpret random variables in various contexts.

COURSE OBJECTIVES:

- Understand the concept of discrete random variables and their probability mass function (pmf), distribution function, and survival function.
- Analyze properties and examples of continuous probability distributions.
- Understand the Jacobian of transformation and its application in transforming random variables.
- Study joint probability mass function and distribution function for two-dimensional random variables.
- Understand moments of a random variable, including mean and variance, and compute them.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Enable to identify the situations involving discrete and continuous random variables
CO2	Explain the concept distribution function and density function.
CO3	Understand the notion of expectation and moments.
CO4	Solve various problems involving expectation and moment generating functions.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Discrete Random Variables: Probability mass function (pmf), discrete probability distribution function (df) and survival function, properties and examples, pmf and df of functions of discrete random variables, mean and variance of a discrete random variable. **(20 Hours)**

UNIT 2

Continuous Random Variables: Probability distribution function and survival function, probability density function (pdf), properties and examples, pdf and df of functions of continuous random variables, Jacobian of transformation, mean and variance of a continuous random variable. **(20Hours)**

UNIT 3

Two Dimensional Random Variables: Joint probability mass function, two dimensional distribution function, marginal distribution function, joint density function, marginal density function, conditional distribution function and conditional probability density function, conditional mean and variance. **(20 Hours)**

UNIT 4

Mathematical Expectation: Definition and properties of expectation, moments of a random variable, mean and variance of a random variable, measures of skewness and kurtosis of a random variable, covariance and correlation between two random variables, moment generating function and its properties. **(20 Hours)**

UNIT 5 (Teacher Specific Module- Optional)

Random Variate Generation: Random variate generation from discrete and continuous distributions using R, computation of mean, variance, correlation and moments of random variable using R, plotting pmf, pdf and df using R.
(10 Hours)

TEXT BOOKS

1. Ross, S. (2010). ***A First Course in Probability***. 8th Ed., Pearson, Prentice Hall.
2. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.

SUGGESTED READINGS

1. Rohatgi, V. K. and Saleh, A. K. M. E. (2015). ***An Introduction to Probability and Statistics***. Wiley.
2. Maria D.U., Ana F.M. and Alan T.A. (2008*): **Probability and Statistics with R.*** CRC Press.
3. Gut, A. (2005). ***Probability: A Graduate Course***. Springer, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester III

A5– DISCIPLINE SPECIFIC CORE COURSE

KU3DSCSTA202: DISTRIBUTION THEORY-I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCSTA202	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of probability distributions and generating functions, focusing on both discrete and continuous distributions. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of various probability distributions and their properties, as well as the use of generating functions for analyzing random variables.

COURSE OBJECTIVES:

- Explore different types of generating functions, including probability generating function (PGF), factorial moment generating function (discrete case only), moment generating function (MGF), and characteristic function, along with their properties.
- Gain familiarity with various standard discrete distributions, including degenerated distribution, discrete uniform distribution, Bernoulli distribution, Binomial distribution, and Poisson distribution.
- Study continuous probability distributions including continuous uniform distribution, normal distribution, standard uniform, and standard normal distributions.
- Learn methods for fitting exponential and gamma distributions to data.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Understand the fundamental concepts of discrete and continuous probability distributions.
CO2	Analyze and interpret advanced discrete distributions including geometric, hypergeometric, and negative binomial distributions, and apply them to solve complex problems.
CO3	Apply statistical inference techniques and hypothesis testing methodologies using sampling distributions.
CO4	Utilize computational tools, particularly R programming language, to implement and illustrate probability distribution concepts effectively.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓		✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit I

Generating Functions: Concepts of independence, independently and identically distributed (i.i.d.) random variables, generating functions- probability generating function (PGF) and factorial moment generating function (discrete case only), moment generating function (MGF), characteristic function and their properties, beta and gamma functions and their properties. **(15 Hours)**

Unit II

Standard Discrete Distributions:- Degenerated distribution, discrete uniform distribution, Bernoulli distribution, Binomial distribution, Poisson distribution, fitting of Binomial and Poisson distributions. Geometric distribution and its lack of memory property, Hypergeometric distribution, Negative binomial distribution and their properties and practical

applications.
(20 Hours)

Unit III

Continuous Distributions I - Continuous uniform distribution, normal distribution, standard uniform and normal distributions, probability integral transformation, area property of normal distribution using standard normal tables, Lognormal distribution, fitting of normal distribution. **(20 Hours)**

Unit IV

Continuous Distributions II- Exponential distribution and its lack of memory property, Gamma distribution, beta distributions of first and second kinds, Laplace distribution, Cauchy distribution, Pareto distribution, Weibull distribution. Fitting of exponential and gamma distributions. **(15 Hours)**

Unit V (Teacher Specific Module- Optional)

Random variate generation using R/SPSS, random variate generation from standard discrete and continuous distributions, fitting of the distributions using generated data. Fitting of a probability distribution for a real life data set and submission of an assignment. **(20 Hours)**

TEXT BOOKS

1. Gupta. S. C and Kapoor. V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons (P) Ltd. New Delhi
2. Krishnamoorthy, K. (2015). ***A Handbook on Statistical Distributions with Applications***. Chapman and Hall/CRC, New York.
3. Bhuyan. K. C. (2010): ***Probability Distribution Theory and Statistical Inference.*** New Central Book Agency (P) Limited.

SUGGESTED READINGS

1. Robert. V. Hogg Allen T. Craig: ***Introduction to Mathematical Statistics***- Macmillan Publishing Co. Inc. NEW YORK.
2. Goon A. M, Gupta M. K. , Das Gupta. B. (1999): ***Fundamentals of Statistics, Vol. I and Vol. II***, World Press, Calcutta.
3. Maria D.U., Ana F.M. and Alan T.A. (2008*):* ***Probability and Statistics with R.*** CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester III

A5– DISCIPLINE SPECIFIC CORE COURSE

KU3DSCSTA203: MATRIX THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCSTA203	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to linear algebra and matrix theory, covering fundamental concepts, operations, and applications of matrices and linear equations. Through a combination of lectures, demonstrations, and practical exercises, students will develop a strong foundation in linear algebra and its applications in various fields.

COURSE OBJECTIVES:

- Gain a solid understanding of matrices, including their definition and basic operations such as addition, subtraction, scalar multiplication, and matrix multiplication.
- Understand the concept of determinants, their definition, properties, and calculation methods.
- Study the inverse of a square matrix, its existence, properties, and calculation methods, including the use of elementary row and column transformations.
- Learn about the characteristic equation and characteristic polynomial of a matrix.

- Study systems of linear equations and represent them using matrix notation.
- Understand the Gaussian elimination procedure and its application in solving systems of linear equations.

COURSE OUTCOME:

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SL #	Course Outcomes
CO1	Demonstrate a thorough understanding of fundamental concepts in matrix theory, including matrix representation, basic operations (addition, subtraction, scalar multiplication, and matrix multiplication), and properties of special matrices
CO2	Compute determinants of square matrices using various methods, understand the properties of determinants, and apply them in calculating inverses of matrices.
CO3	Grasp the concepts of eigenvalues and eigenvectors, their significance in linear algebra, and their applications in diagonalizing matrices.
CO4	Acquire problem-solving skills in systems of linear equations, including representation using matrix notation, determination of solutions, and application of methods such as Gaussian elimination and Cramer's rule.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

COURSE CONTENTS

Unit I

Basics of Matrices: Introduction to matrices, matrix operations: addition, subtraction, scalar multiplication, matrix multiplication and properties, transpose of a matrix, special matrices: square matrix, diagonal and triangular matrices, identity matrix, diagonal matrix, symmetric matrix, skew symmetric matrix, idempotent matrix, stochastic matrix, orthogonal matrices. **(15 Hours)**

Unit II

Determinants and Inverses: Determinants: definition, properties, and calculation methods, adjoint and minors of a square matrix, Inverse of a square matrix: existence, properties, and calculation methods, computation of inverse using elementary row and column transformations. Properties of invertible matrices, applications of determinants and inverses. **(20 Hours)**

Unit III

Eigenvalues and Eigenvectors: Eigenvalues and eigenvectors: definition and basic properties, characteristic equation and characteristic polynomial, Cayley-Hamilton theorem and its applications, diagonalization of matrices, powers of a square matrix using eigenvalues and eigenvectors, trace and determinants of square matrix. **(20Hours)**

Unit IV

Systems of Linear Equations: Linear equation and solutions, system of linear equations, matrix representation, augmented and coefficient matrices of a system, degenerate linear equations, equivalent systems, elementary operations, elimination algorithm, systems in triangular and echelon forms, echelon form, pivot and free variables, Gaussian elimination procedure, Cramer's rule and its applications. **(20 Hours)**

Unit V (Teacher Specific Module- Optional)

Numerical computation of various characteristics and operations of matrices and solution of system of linear equations using R. **(15 Hours)**

TEXT BOOKS

1. Lipschutz, S. (2009). ***Linear Algebra (4th ed***.). McGraw-Hill.
2. Lay David C. (2000). ***Linear Algebra and Its Applications***, Addison Wesley

SUGGESTED READINGS

1. Gupta S.C. (2008). ***An Introduction to Matrices***. Sultan Chand & Sons. New Delhi
2. Datta K.B. (2002). ***Matrix and Linear Algebra.*** Prentice Hall of India Pvt. Ltd.
3. Searle S.R. (1982). ***Matrix Algebra Useful for Statistics***. John Wiley &Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Semester III

A6– DISCIPLINE SPECIFIC CORE COURSE

KU3DSCSTA204: STATISTICAL COMPUTING USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCSTA204	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

The course provides a comprehensive introduction to IBM SPSS Statistics, a powerful software package widely used for statistical analysis in various fields. It is divided into four modules, each covering specific aspects of SPSS functionality and statistical analysis techniques. Throughout the course, students will engage in practical exercises and real-world applications to reinforce their understanding of SPSS and statistical analysis techniques. By the end of the course, students will have acquired the skills necessary to effectively utilize SPSS for data management, analysis, and presentation in their academic or professional endeavors.

COURSE OBJECTIVES:

- Understanding SPSS Fundamentals: By the end of the course, students should be proficient in navigating the SPSS interface, entering and managing data, defining variables, and utilizing essential features for data manipulation and organization.
- Data Visualization and Presentation Skills: Students will develop the ability to create a variety of graphs and visualizations using SPSS, and they will learn how to customize these visuals for effective communication of statistical findings in reports, presentations, and academic papers.
- Exploratory Data Analysis Proficiency: The course aims to equip students with the skills necessary to conduct exploratory data analysis using SPSS, including generating frequency distributions, summary tables, and basic visualizations to understand the characteristics and distribution of data.
- Statistical Analysis Competence: Students will gain competence in performing basic statistical analyses such as correlation analysis and linear regression using SPSS. They will learn how to interpret statistical output, assess model fit, and report results in a clear and concise manner.
- Practical Application and Problem-Solving: Through hands-on exercises and real-world examples, students will develop problem-solving skills and learn how to apply SPSS techniques to analyze and interpret data from various fields, preparing them for practical use in academic research, business analytics, or other professional contexts.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Demonstrate proficiency in using IBM SPSS Statistics software for various tasks including data entry, manipulation, analysis, and visualization. They will be able to navigate the SPSS interface confidently and utilize its features effectively to manage and analyze datasets.
CO2	Develop the ability to conduct basic statistical analyses using SPSS and interpret the results accurately. This includes performing descriptive statistics, correlation analysis, and simple linear regression, as well as understanding the assumptions and limitations associated with these analyses.

CO3	Learn how to create informative and visually appealing graphs and charts using SPSS, and they will be able to tailor these visualizations to effectively communicate their findings to various audiences. They will also gain skills in preparing SPSS output for inclusion in reports, presentations, and academic papers.
CO4	Develop critical thinking skills and learn how to apply statistical concepts and methods to solve problems and make informed decisions. They will be able to evaluate the appropriateness of different statistical techniques for analyzing specific types of data and research questions.

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MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

COURSE CONTENTS

Module 1:

Introduction to SPSS: What is SPSS?, Versions of IBM SPSS Statistics, Getting started, Opening SPSS, Layout of SPSS, Structure of SPSS, Exiting SPS, An overview of SPSS, The data editor, Entering data into the data editor, The variable view, Creating a string variable, Creating a date variable, Creating coding variables, Creating a numeric variable, Missing values, Importing data, The SPSS viewer, Exporting SPSS output, The syntax editor, Saving files, Retrieving a file.
(15 Hours)

Module 2:

Graphics in SPSS: Exploring data with graphs, The art of presenting data, The SPSS chart builder, Histograms, Further histogram options, Boxplots (box–whisker diagrams), bar charts and error bars, Simple bar charts for independent means, Clustered bar charts for independent means, Simple bar charts for related means, Clustered bar charts for related means, Line charts, the scatterplot, Grouped scatterplot, Matrix scatterplot, density plot, Editing graphs. **(20 Hours)**

Module 3:

Exploring data distributions using descriptive statistics, Creating frequency distributions and summary tables, Generating basic visualizations (e.g., histograms, box plots) in SPSS. Computing measures of dispersion, Understanding correlation and covariance, Performing correlation analysis in SPSS, Data entry for correlation analysis using SPSS, General procedure for running correlations in SPSS, Running Pearson's r in SPSS, Spearman's correlation coefficient, Kendall's tau, How tor eport correlation coefficients. **(25 Hours)**

Module 4 :

Introduction to linear regression and its application in SPSS, The simple linear model, Running a simple regression using SPSS, Interpreting a simple regression, Model parameters, Understanding hypothesis testing principles, Conducting hypothesis tests in SPSS, Interpreting SPSS output for hypothesis testing. **(15 Hours)**

Unit V (Teacher Specific Module- Optional)

The t-test, Independent-samples t-test, Paired-samples t-test, The independent t-test using SPSS, Output from the independent t-test, Reporting the independent t-test, Paired-samples t-test using SPSS, Output from the paired-samples t-test, Reporting the paired-samples t-test **(15 Hours)**

TEXT BOOKS

1. Field, A. (2013). ***Discovering Statistics Using IBM SPSS Statistics***. Sage Publications.
2. Landau, S., & Everitt, B. S. (2003). ***A Handbook of Statistical Analyses Using SPSS***. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Aldrich, J. O. (2018). ***Using IBM SPSS statistics: An Interactive Hands-on Approach*.** Sage Publications.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Semester IV

A8– DISCIPLINE SPECIFIC CORE COURSE

KU4DSCSTA205: DISTRIBUTION THEORY-II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCSTA205	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+3(P)*

COURSE DESCRIPTION:

This course provides an advanced exploration of probability distributions, focusing on key concepts such as the Weak Law of Large Numbers, Central Limit Theorems, Sampling Distributions, and Bivariate Normal Distribution. Through lectures, discussions, and practical examples, students will develop a deep understanding of these theoretical principles and their applications in statistical analysis.

COURSE OBJECTIVES:

- Study the weak law of large numbers, including Bernoulli's weak law of large numbers and Chebyshev's weak law of large numbers.

- Analyze examples and applications of the weak law of large numbers in various contexts.
- Analyze examples and applications of central limit theorems in real-world scenarios.
- Define a statistic and understand the concept of sampling distribution of a statistic.
- Understand joint, marginal, and conditional distributions in the context of the bivariate normal distribution.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Understanding of probability inequalities and convergence in random variables
CO2	Develop proficiency in central limit theorems, including convergence in distribution, DeMoivre-Laplace Central limit theorem..
CO3	Gain expertise in sampling distributions and statistical inference, including the distribution of sample mean and variance, chi-square distribution, Student's t distribution, and F-distribution.
CO4	Acquire basic knowledge of bivariate distributions, their marginal and conditional distributions.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓

CO3	✓	✓	✓	✓	✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

Unit I

Weak Law of Large Numbers- Chebychev's inequality, convergence in probability (definition only), weak law of large numbers, Bernoulli's weak law of large numbers, Chebychev's weak law of large numbers, examples and applications. **(20 Hours)**

Unit II

Central Limit Theorems: Convergence in distribution (definition only), De Moivre-Laplace central limit theorem, Lindberg-Levy form of central limit theorem, normal approximation for the computation of probabilities related to binomial and Poisson models, examples and applications. **(20 Hours)**

Unit III

Sampling Distributions: Definition of Statistic, sampling distribution of a statistic and standard error; distribution of sample mean and sample variance when the sample is from a normal population; Chi square distribution-mean and variance, MGF, additive property; Student's t distribution – mean and variance; F-distribution– mean and variance; inter-relationships between Chi square, t, and F distributions. **(20 Hours)**

Unit IV

Bivariate Normal Distribution: Joint, marginal, and conditional distributions, independence, covariance and correlation matrices, conditional mean as regression function, estimates of mean vector and covariance matrix; multinomial distribution as a generalization of binomial distribution and its properties. **(20 Hours)**

Unit V (Teacher Specific Module- Optional)

Illustration of WLLN and CLT using R. Sample generation from bivariate normal distribution, two dimensional density plots and computation of variance covariance matrix using simulated data. R commands to evaluate area under t, F and chi-square distributions. **(10 Hours)**

TEXT BOOKS

1. Gupta. S. C & Kapoor. V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons (P) Ltd. New Delhi

2. Bhuyan. K. C. (2010): ***Probability Distribution Theory and Statistical Inference***. New Central Book Agency (P) Limited.

SUGGESTED READINGS

1. Krishnamurthy, K. (2006). ***Handbook of Statistical Distributions with Applications***. Chapman & Hall/CRC, New York.
2. Hogg, R.V. and Craig, A.T. ***Introduction to Mathematical Statistics***- Macmillan Publishing Co. Inc. NEW YORK.
3. Goon A. M, Gupta M. K. and Das Gupta. B. (1999): ***Fundamentals of Statistics, Vol. I and Vol. II***, World Press, Calcutta.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IV

A9–DISCIPLINE SPECIFIC CORE COURSE

KU4DSCSTA206: SAMPLING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCSTA206	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of sampling techniques and survey methodology, focusing on the principles, applications, and practical considerations involved in conducting sample surveys. Through lectures, discussions, and hands-on exercises, students will develop a comprehensive understanding of various sampling methods and their implications for estimating population quantities.

COURSE OBJECTIVES:

- Understand the definition, importance, and applications of sampling in statistical analysis.
- Understand the basic types of sampling techniques: probability sampling and non-probability sampling.
- Understand the concepts of accuracy and precision of estimates, and identify biases in surveys.
- Learn methods for estimating population mean and total under systematic sampling, and calculate variances of these estimates.
- Define stratified sampling and cluster sampling and understand their respective advantages and applications.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Grasp the fundamental principles of sampling, including its definition, importance, and applications in various fields
CO2	Acquire proficiency in estimating population parameters using different sampling techniques.
CO3	Develop the ability to discern between different types of sampling techniques and understand their respective advantages, limitations.
CO4	Demonstrate proficiency in implementing sampling methodologies and analyzing sample data using computational techniques.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Overview of Sampling: Definition, importance and applications, population vs. sample. Basic principles of sample surveys, advantages of sample survey over census. Different steps in a large scale sample survey, understanding the basic types of sampling techniques: probability sampling and non-probability sampling, sampling and non sampling errors, sample size determination. **(20 Hours)**

UNIT 2

Estimation of population quantities: Accuracy and precision of estimates, Bias in surveys, Probability Sampling:- Simple Random Sampling, simple random sampling with replacement (SRSWR) and without replacement (SRSWOR), estimation of population mean, variance of sample mean and comparison of SRSWR and SRSWOR, Numerical illustrations.

(20 Hours)

UNIT 3

Systematic Sampling: Definition, linear systematic sampling, circular systematic sampling, estimates of population mean and total, variances of these estimates (N = nxk). Comparison of systematic sampling with SRS. Numerical illustrations.

(20 Hours)

UNIT 4

Introduction to Stratified Sampling and Cluster Sampling: Definitions of stratified and cluster sampling, estimation of population mean and total under stratified and cluster sampling, computation of standard error**,** Numerical illustrations.

(20 Hours)

UNIT 5 (Optional)

Computational illustration of above concepts using R packages for sampling. Sample size calculation using specified packages.

(15 Hours)

TEXT BOOKS

1. Daroga Singh, Fauran S. Chaudhary (2010). ***Theory and Analysis of Sample Survey Designs.*** John Wiley.
2. Gupta. S. C & Kapoor. V. K. (2002): ***Fundamentals of Applied Statistics***, Sultan Chand & Sons (P) Ltd.

SUGGESTED READINGS

1. Cochran W.G. (1984): ***Sampling Techniques(3rd Ed.)***, Wiley Eastern.
2. Sukhatme, P. V., Sukhatme, B. V. Sukhatme, S. Asok, C.(1984). ***Sampling Theories of Survey With Application,*** IOWA State University Press and Indian Society of Agricultural Statistics.

3. Murthy M.N. (1977): ***Sampling Theory & Statistical Method***s, Statistical Pub. Society, Calcutta.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT enabled lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IV

A10– DISCIPLINE SPECIFIC CORE COURSE

KU4DSCSTA207: THEORY OF ESTIMATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCSTA207	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive overview of statistical estimation techniques and inference methods, focusing on both point and interval estimation for parametric models.

Through lectures, demonstrations, and practical examples, students will gain a deep understanding of the principles and properties of various estimation methods and their applications in statistical analysis.

COURSE OBJECTIVES:

- Understand the concept of parameters in statistical models, parameter space, and families of parametric models.
- Study the concepts of bias and mean squared error (MSE) of an estimator, as well as variance of an estimator.
- Understand the concepts of minimum variance unbiased estimator (MVUE), Cramer-Rao inequality, Fisher's information, and efficiency.
- Explore different methods of estimation including method of moments, method of Maximum Likelihood Estimation (MLE), and method of minimum variance.
- Learn methods for constructing confidence intervals for parameters of normal, exponential, and other standard distributions.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Comprehend the notion of a parameter, parameter space, and the concept of point and interval estimation.
CO2	Acquire proficiency in applying the method of maximum likelihood estimation to derive estimators for parameters of standard distributions.
CO3	Acquire proficiency in applying the method of maximum likelihood estimation to derive estimators for parameters of standard distributions.
CO4	Understand the criteria for evaluating estimators such as minimum variance bound estimator (MVB)

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Parametric models: Notion of a parameter, parameter space, family of parametric models, examples of parametric families of distributions, point and interval estimation. Point Estimation: Definition of an estimator, distinction between estimator and estimate, bias and mean squared error (MSE) of an estimator, variance of an estimator. **(20 Hours)**

UNIT 2

Point Estimation – Point estimation, desirable properties of a good estimator-unbiasedness, example of an absurd estimator but unbiased, consistency, sufficient conditions for consistency, invariance property of consistency, sufficiency, Fisher-Neyman factorization theorem (without proof), efficiency; minimum variance unbiased estimator (MVUE), Cramer-Rao inequality and minimum variance bound (MVB) estimators, Fisher's information.**(20 Hours)**

UNIT 3

Methods of Estimation: Method of moments, properties of moment estimators (Statement only), Method of Maximum Likelihood, Properties of MLE (statement only), Method of minimum variance, Examples- Normal and Gamma when one parameter is known and when both the parameters are unknown, Uniform, Binomial, Poisson and exponential and other well known standard distributions. **(20 Hours)**

UNIT 4

Interval Estimation: Concept of confidence interval, pivotal quantity, small sample confidence intervals, confidence intervals for mean and variance of normal population; confidence interval for the difference of means and variance of two independent normal populations with same variance, confidence intervals for ratio of variances of two independent normal population, confidence interval for parameter of exponential distribution, large sample confidence intervals based on CLT for population mean, difference of means, population proportion and difference of proportions using binomial sampling scheme, mean of a Poisson distribution. **(20 Hours)**

UNIT 5

Sample generations from standard distributions using R, computation of estimators and confidence intervals using generated samples. Computation of bias and MSE. **(10 Hours)**

TEXT BOOKS

1. Dudewicz, E.J. and Mishra, S.N. (1988). ***Modern Mathematical Statistics***, John Wiley and Sons,nc.
2. Buyan, K. C. (2010) ***Probability Theory and Statistical Inference*** , 1stEdn New Central Book Agency
3. Mood, A.M. Graybill, and .Boes, D. (2017). ***Introduction to Theory of Statistics***, 3rdEdn.,McGraw Hill Series.

SUGGESTED READINGS

1. Hoel, P.G. Port, S. and Stone, C.(1972). ***Introduction to Statistical Theory***, Houghton Mifflin Company (International) Dolphin Edition
2. V.K. Rohatgi and Saleh A. K. Md. E. (2015). ***An Introduction to Probability Theory and Statistics,*** 3rdEdn. Wiley, New York
3. B.W. Lindgren (1993). ***Statistical Theory***, 4thEdn., CRC Press, London

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IV

A11– DISCIPLINE SPECIFIC CORE COURSE

KU4DSCSTA208:INTRODUCTION TO BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCSTA208	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of biostatistical methods and epidemiological techniques used in public health research and analysis. Through lectures, discussions, and practical applications, students will develop the knowledge and skills necessary to understand and interpret proportions, rates, ratios, odds, and correlation coefficients in biomedical research.

COURSE OBJECTIVES:

- Understand the fundamental concepts of proportions, rates, ratios, and odds in biomedical research and epidemiology.
- Learn the principles and techniques of comparative studies and screening tests used in public health research.
- Understand the measures of morbidity and mortality and their applications in epidemiological studies.
- Understand the concepts of relative risk, odds, and odds ratio and their role in epidemiological analysis.

COURSE OUTCOME:

After successful completion of this course, students will be

SL #	Course Outcomes
CO1	Proficient in analyzing proportions and rates in comparative studies, screening tests, and displaying proportions effectively.
CO2	Develop a comprehensive understanding of ratios, including relative risk, odds, odds ratio, and generalized odds for ordered 2xk tables.
CO3	Equipped to handle special cases of binary data and understand coefficients of correlation, including Pearson's correlation coefficient and nonparametric correlation coefficients.
CO4	Proficiency in analyzing one-sample problems with binary data, conducting analysis of pair-matched data, and comparing two proportions using the Mantel-Haenszel method.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

UNIT 1

Proportions and Rates: Comparative Studies, Screening Tests, Displaying Proportions. Rates:- Changes, Measures of Morbidity and Mortality, Standardization of Rates.

(20 Hours)

UNIT 2

Ratios and Odds: Relative Risk, Odds and Odds Ratio, Generalized Odds for Ordered 2xk Tables, Mantel–Haenszel Method, Standardized Mortality Ratio.

(20 Hours)

UNIT 3

Special Case of Binary Data: Coefficients of Correlation, Pearson's Correlation coefficient, Nonparametric Correlation coefficients. Practical applications of Normal, Binomial and Poisson distributions in biomedical research, Pair-Matched Case–Control Study.

(20 Hours)

UNIT 4

Mantel–Haenszel Method: One-Sample Problem with Binary Data, Analysis of Pair-Matched Data, Comparison of Two Proportions, Mantel–Haenszel Method.

(15 Hours)

UNIT 5

Computational illustration of above concepts using R. Various examples from medical research **(15 Hours)**

TEXT BOOK

1. Chap T.L. (2003). ***Introductory Biostatistics***, John Wiley & Sons.

SUGGESTED READINGS

1. Rosner, B. (2010). ***Fundamentals of Biostatistics*****,** Cengage Learning, Harvard University.
2. Chernick, M.R. and Fris, R.H. (2003). ***Introductory Biostatistics for the Health Sciences**,* John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester V

A12– DISCIPLINE SPECIFIC CORE COURSE

KU5DSCSTA301:THEORY OF MARKOV CHAIN

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCSTA301	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Theory of Markov Chain is a foundational course in probability theory and statistical modeling, focusing on the study of random processes evolving over time or space. The course covers various types of stochastic processes, including discrete-time, discrete-state processes, Markov chains, and continuous-time processes such as Poisson processes. Emphasis is placed on understanding the fundamental properties and applications of these processes in modeling real-world phenomena across different fields.

COURSE OBJECTIVES:

- Define stochastic processes and their significance in modeling systems with randomness.
- Understand the concepts of state space and time space in stochastic processes.
- Define Markov chains and their key characteristics, including transition probabilities and states.
- Study the limiting behavior of Markov chains, including initial and stationary distributions.
- Understand the postulates for Poisson processes and their properties, such as interarrival time.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Develop a solid understanding of stochastic processes, including their definition, classification, and basic properties.
CO2	Gain proficiency in Markov chains, understanding their definition, transition probabilities, state space, and transition probability matrix.
CO3	Analyze Markov processes with discrete state space, including the Poisson process, pure birth process, and birth and death process.
CO4	Grasp the concept of Markov chains, including transition probabilities, state space, and transition probability matrices.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Stochastic Processes: Definition of a stochastic process, examples, state space, time space, discrete time discrete state stochastic process, basic properties, examples, stationary processes, strict stationary process and weak stationary process, Markov property**.**

(15 Hours)

UNIT 2

Markov Chains: Definition, transition probabilities, transition probability matrix and its properties, examples, higher order transition probabilities, Chapman-Kolmogorov equations. Probability distribution, Strong Markov property, order of a Markov chain, Markov chains as Graphs, random walk. **(20 Hours)**

UNIT 3

Classification of States: Communication relations, class property, Transience, recurrence, periodicity, first passage time distribution. limiting behavior of Markov chains: initial distribution and stationary distributions, ergodicity, ergodic theorem.
(20 Hours)

UNIT 4

Continuous Time Markov Chain: Continuous time random process, Poisson Process, postulates for Poisson process, properties of Poisson process, interarrival time, introduction to Markov-Chain Monte Carlo (MCMC) methods.
(20 Hours)

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOKS

1. Medhi, J. (1994). ***Stochastic processes***. New Age International.
2. Norris JR (1998). ***Markov Chains***. Cambridge Series.

SUGGESTED READINGS

1. Madhira, S., & Deshmukh, S. (2023). ***Introduction to Stochastic Processes Using R***. Springer.
2. Ross, S. M. (1996). ***Stochastic Processes (2nd Ed.)***. New York: John Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester V

A13– DISCIPLINE SPECIFIC CORE COURSE

KU5DSCSTA302: MATHEMATICAL METHODS FOR STATISTICS-I

Semester	Course Type	Course Level	Course Code		Credits	Total Hours
5	CORE	300	KU5DSCSTA302		4	75
Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hour/*/s)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	3(T)

COURSE DESCRIPTION:

This course provides a comprehensive introduction to fundamental mathematical concepts in calculus and analysis. Starting with sequences and limits, the course progresses to series, functions of a single variable, the Riemann integral, and an introduction to complex analysis. Emphasis is placed on understanding the theoretical foundations of calculus and developing problem-solving skills through rigorous mathematical reasoning.

COURSE OBJECTIVES:

- Gain a solid understanding of set theory, properties of the real number system, and the basics of complex analysis.
- Study sequences and their limits, including limit theorems and convergence criteria such as the Cauchy criteria.
- Analyze different types of series and their convergence properties using tests such as the comparison test, root test, and ratio test.
- Study limits and continuity of functions, including continuity at a point and on closed intervals.
- Define and comprehend the Riemann integral, including its existence and properties.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Understand the fundamental concepts of analysis, including set theory, properties of the real number system, and sequences.
CO2	Apply various convergence tests and criteria for series convergence, including the comparison test, Cauchy's root test, and D'Alembert's ratio test
CO3	Proficiency in understanding series, convergence tests, and criteria for convergence.
CO4	Apply properties of functions of a single variable, limits of functions, continuity, types of continuity, and the maximum-minimum theorem.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

UNIT 1

Sequences and Limits: Basics of set theory, properties of real number system, sequences and their limits, limit theorems, monotone sequence, subsequences, Bolzano-Weierstrass theorem, Cauchy criteria. **(12 Hours)**

UNIT 2

Series and Convergence: Definition of series, positive term series, comparison test, Cauchy's root test, D'Alembert's ratio test, Raabe's test, logarithmic test, alternative series, Leibnitz test, absolute convergence and conditional convergence, power series, radius of convergence. **(18 Hours)**

UNIT 3

Functions of Single Variable: Limits of a function, continuous function, continuity at a point, continuity in closed interval, types of continuity, continuity on closed intervals, maximum-minimum theorem, uniform continuity, Weierstrass approximation theorem. **(15 Hours)**

UNIT 4

The Riemann Integral: Definition and existence of the integral, partitions, refinement of partitions, conditions of integrability, properties of Riemann integral, integral as a limit of sums. Integrability of continuous and monotonic functions. **(15 Hours)**

UNIT 5(Optional)

Introduction to complex analysis, complex number system, Complex functions-analytic function, Cauchy- Riemann equation, harmonic function, necessary condition for a function to be analytic, sufficient condition for function to be analytic. Complex integration. **(15 Hours)**

TEXT BOOKS

1. Robert G Bartle (2000). ***Introduction to Real Analysis***, **4th Edition,** Wiley Eastern Ltd.
2. James Ward Brown, Paul Churchill (2009). ***Complex Variables and Applications***, **8 th Edition**, McGraw Hill.

SUGGESTED READINGS

1. S.C.Malik & Savita Arora. (2017). ***Mathematical Analysis***, **5th Edition**, Wiley Eastern Ltd.

2. Shanti Narayanan(2003). ***Elements of Real Analysis***, Sultan Chand & Sons.
3. Goldberg, R. R. (2020). ***Methods of Real Analysis***. Oxford and IBH Publishing.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to Section 7 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 4 Credit Theory.

Semester V

A14– DISCIPLINE SPECIFIC CORE COURSE

KU5DSCSTA303: LINEAR REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCSTA303	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Regression Analysis is a fundamental course in statistics that focuses on modeling the relationship between a dependent variable and one or more independent variables. This course provides a comprehensive introduction to correlation analysis, simple linear regression, inference in regression, and goodness of fit of regression models. Emphasis is placed on understanding the underlying principles, assumptions, and interpretation of regression models, as well as practical applications in various fields.

COURSE OBJECTIVES:

- Develop a solid understanding of the principles underlying regression analysis, including correlation, linear regression models, and inference techniques.
- Master techniques for modeling relationships between variables using regression models, including simple linear regression and alternative regression methods.
- Apply regression analysis techniques to real-world data sets to analyze relationships between variables and make predictions.
- Develop the ability to interpret regression results, including coefficient estimates, hypothesis tests, confidence intervals, and measures of goodness of fit.
- Evaluate the goodness of fit of regression models and assess their predictive capabilities using measures such as the coefficient of determination and prediction intervals.

COURSE OUTCOME:
After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Develop a thorough understanding of correlation analysis, including its definition and various types such as Pearson correlation coefficient, Spearman rank correlation coefficient, and Kendall's tau.
CO2	Proficient in formulating simple linear regression models, understanding their assumptions, and interpreting the results.
CO3	Perform inference in regression analysis using methods such as Ordinary Least Squares (OLS) estimation and maximum likelihood estimation.
CO4	Learn inference techniques for regression analysis, including OLS estimation, maximum likelihood estimation, hypothesis testing, and confidence interval estimation for regression parameters.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Introduction to Correlation Analysis: Definition of correlation, types of correlation: Pearson correlation coefficient, Spearman rank correlation coefficient, Kendall's tau, Properties of correlation coefficients, Interpretation of correlation coefficients, Significance testing for correlation coefficients, Scatter plot. **(15 Hours)**

UNIT 2

Introduction to Regression Analysis: Simple linear regression model: Model formulation, assumptions, and interpretation, orthogonal regression, reverse (or inverse) regression method, reduced major axis regression method, least absolute deviation regression, Centered Model, No intercept term model. **(20 Hours)**

UNIT 3

Inference in Regression: Method of Ordinary Least Squares (OLS) estimation, Method of maximum likelihood estimation, Testing of hypotheses and confidence interval estimation for slope parameter and for intercept term. Confidence interval for error variance. **(20 Hours)**

UNIT 4

Goodness of fit of Regression: ANOVA, coefficient of determination, prediction of values of study variable, prediction interval estimation, prediction of actual value, estimation of parameters when regressors are stochastic (Concept only). **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. (Practical) **(20 Hours)**

TEXT BOOKS

1. Montgomery, D. C., Peck, E. A., and Vining, G. G. (2021). ***Introduction to Linear Regression Analysis***. John Wiley & Sons.
2. Faraway, J. J. (2002). ***Practical Regression and ANOVA Using R*** **(Vol. 168)**. University of Bath.

SUGGESTED READINGS

1. Monahan, J. F. (2008). ***A Primer on Linear Models***. CRC Press.
2. Khuri, A. I. (2009). ***Linear Model Methodology***. Chapman and Hall/CRC.
3. Gujarati, D. N., & Porter, D. C. (2009). ***Basic Econometrics*.** McGraw-Hill.
4. Draper, N. R., & Smith, H. (1998). ***Applied Regression Analysis*** . John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester V

A15– DISCIPLINE SPECIFIC CORE COURSE

KU5DSCSTA304: TESTING OF HYPOTHESIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCSTA304	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Statistical Hypothesis Testing is a fundamental course in statistics that focuses on testing hypotheses about population parameters based on sample data. This course provides a comprehensive introduction to statistical hypotheses, including null and alternative hypotheses, critical regions, Type I and Type II errors, and various hypothesis tests for different types of data distributions. Emphasis is placed on understanding the principles of hypothesis testing, choosing appropriate tests for different scenarios, and interpreting test results.

COURSE OBJECTIVES:

- Develop a comprehensive understanding of the principles of hypothesis testing, including null and alternative hypotheses, Type I and Type II errors, and significance levels.
- Master various hypothesis testing techniques for different types of data distributions, including small and large samples, as well as parametric and non-parametric tests.
- Learn how to apply hypothesis testing procedures to real-world scenarios, including choosing appropriate tests, conducting tests, and interpreting results effectively.
- Develop the ability to interpret the results of hypothesis tests accurately and draw

meaningful conclusions based on statistical evidence.

- Enhance critical thinking skills and problem-solving abilities necessary for statistical analysis and decision-making in various fields.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate proficiency in hypothesis testing methodologies, including formulating null and alternative hypotheses, understanding the concepts of Type I and Type II errors, and interpreting p-values.
CO2	Gain a deep understanding of advanced testing techniques, such as the Neymann-Pearson lemma and likelihood ratio tests.
CO3	Learn when and how to apply parametric and non-parametric tests, interpret results, and draw valid conclusions from statistical analyses.
CO4	Gain practical experience in implementing statistical tests and visualizing results.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Statistical Hypotheses: Simple and composite hypotheses, null and alternative hypotheses, critical region, best critical region (BCR), acceptance region, Type I and Type II errors, size and power of a test, most powerful tests, p-value, Neymann -Pearson Lemma, computation of BCR based on Binomial, Poisson, Normal and Exponential distributions. **(20 Hours)**

UNIT 2

Small Sample/Exact Tests : Tests based on samples from a normal population**:-** z-tests for one sample and two sample cases, one sample t-test, independent sample t-test, paired t-test, Levene's test, test for significance of correlation coefficient, chi-square test for significance of variance, F-test for equality of variances, test for significant difference between two correlation coefficients. **(15 Hours)**

UNIT 3

Large Sample Tests and Chi-square Tests: Tests based on normal approximation- tests for significance of mean, equality of means, significance of proportion and equality of two proportions, tests based on Chi-square distribution: Chi-square test for goodness of fit, test for homogeneity and independence of attributes, tests for significance of variance. **(20 Hours)**

UNIT 4

Tests for Normality and Non- Parametric Tests:Q-Q plot, P-P plot, Shapiro-Wilks's test for normality of data; One sample tests- run test, test for randomness, sign test, signed rank test. Two sample tests-Mann-Whitney 'U' Test, Median test, Kolmogrov-Smirnov test for one sample and two sample cases. The Kruskal-Wallis Test.

(20 Hours)

UNIT 5 (Optional)

Computational illustration of above concepts using simulated data from standard distributions using R. **(15 Hours)**

TEXT BOOKS

1. B.W. Lindgren (2017). ***Statistical Theory***, 4thEdn., CRC Press, London.
2. Buyan, K. C. (2010). ***Probability Theory and Statistical Inference,1 stEdn.*** New Central Book Agency. .

SUGGESTED READINGS

1. V.K. Rohatgi and Saleh A. K. Md. E. (2015). ***An Introduction to Probability Theory and Statistics***, 3rdEdn. Wiley, New York .
2. Daniel, W.W. (2000). ***Applied Nonparametric Statistics,*** Duxbury Press Boston
3. Mood, A.M. Graybill, F.Boes, D. (2017). ***Introduction to Theory of Statistics, 3rd Edn***., Mc-Graw Hill Series.
4. Kale, B. K. (2005). ***A First Course on Parametric Inference.*** Alpha Science Int'l Ltd..

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester V

DSE1– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA305: INTRODUCTION TO ACTUARIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU5DSESTA305	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Actuarial Statistics is a specialized course that focuses on the mathematical principles and techniques used in the insurance industry. This course provides a comprehensive introduction to the insurance business, actuarial science, life tables, present values, annuities, and premium calculations. Emphasis is placed on understanding the concepts, models, and calculations used in insurance mathematics and their practical applications in risk management and insurance products.

COURSE OBJECTIVES:

- Develop a comprehensive understanding of the insurance industry, including its role as a financial intermediary and risk management tool.
- Acquire proficiency in actuarial science principles, including the calculation of future lifetime distributions, life tables, and present values.
- Learn to analyze various insurance products, including life insurance policies and annuities, using mathematical techniques such as present value calculations and premium calculations.
- Apply mathematical models and techniques to assess risk, price insurance products, and determine appropriate premium levels.
- Enhance problem-solving skills and critical thinking abilities in the context of insurance mathematics through practical exercises and real-world applications.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of insurance and utility theory, including the concepts of risk aversion, utility functions, and decision-making under uncertainty.
CO2	Proficiency in modeling individual insurance claims using probability distributions such as Poisson, exponential, and gamma distributions.
CO3	Understand survival functions, curtate future lifetime, and the force of mortality.
CO4	Apply life tables to analyze mortality and survival patterns.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Insurance Business: Introduction, actuarial science, insurance Companies as business organizations, concept of risk, operation of the Insurance Business, role of statistics in insurance, insurance business in India, expected value principle, notion of utility, risk models for short term. **(15 Hours)**

UNIT 2

Future Lifetime Distribution and Life Tables: Future lifetime random variable, curtate future- lifetime, life tables, construction of life tables, assumptions for fractional ages, select and ultimate life tables, numerical examples.
(15 Hours)

UNIT 3

Actuarial Present Values and Annuities: Concept of present values, actuarial present values of benefit in life insurance products, compound interest and discount factor, benefit payable at the moment of death, benefit payable at the end of year of death, introduction to annuities, annuities certain, continuous life annuities,discrete life annuities, life annuities with monthly payments. **(15 Hours)**

UNIT 4

Premiums: Introduction to premium calculations, loss at issue random variable, fully continuous premiums, fully discrete premiums, true monthly payment premiums, gross premiums, introduction to multiple life contracts. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOK

1. Deshmukh, S. R. (2009). ***Actuarial Statistics: An Introduction Using R***. Universities Press (India).
2. Beard, R.E., Penlikainen, T. and Pesonnen, E (1984): ***Risk Theory: The Stochastic Basis of Insurance, 3rd Edition***, Chapman and Hall, Londan.

SUGGESTED READINGS

1. Bowers, N.L., Gerber, H.U., Hickman, J.E., Jones, D.A. and Nesbitt, C.J. (2014): ***Actuarial Mathematics, Society of Actuaries,*** Ithaca, Illiois, U.S.A., second Edition.
2. Neill, A. (1977): ***Life Contingencies***, Heineman.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

SEMESTER V

DSE2-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU5DSESTA306: OFFICIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU5DSESTA306	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Official Statistics is a foundational course that introduces students to the structure and function of statistical systems at the state, national, and international levels. This course also covers vital statistics, including fertility, mortality, and demographic methods, as well as index numbers used in economic analysis. Emphasis is placed on understanding the role of statistical organizations, methods of data collection, and the calculation and interpretation of vital statistics and index numbers.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of the structure, functions, and activities of central and state statistical organizations, as well as their role in data collection, analysis, and dissemination.
- Acquire proficiency in vital statistics concepts, including fertility, mortality, and migration rates, and learn how to calculate and interpret these statistics accurately.
- Develop skills in analyzing demographic data from various sources, such as census, registers, surveys, and hospital records, and understand how to interpret demographic profiles and life tables.
- Learn the principles of index numbers, including their definition, construction methods, and applications in economic analysis. Gain proficiency in constructing and interpreting simple and weighted index numbers, including consumer price index numbers.
- Apply statistical methods and techniques learned in the course to analyze real-world data sets related to population demographics, economic trends, and index numbers. Develop the ability to draw meaningful insights and conclusions from statistical analysis.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Calculate and interpret vital statistics, including fertility rates, mortality rates, and migration rates, using appropriate statistical methods and techniques. They will demonstrate proficiency in analyzing demographic data and drawing meaningful insights from vital statistics.
CO2	Construct and interpret index numbers, including consumer price index numbers, and apply them in economic analysis. They will understand the significance of index numbers in measuring inflation, price changes, and economic trends, and be able to use them to make informed decisions.
CO3	Develop the ability to interpret demographic profiles and life tables accurately. They will understand the components of life tables, including survival probabilities and mortality rates, and be able to analyze demographic data from various sources to assess population demographics and trends.
CO4	Evaluate the structure, functions, and activities of central and state statistical organizations. They will understand the role of these organizations in data collection, analysis, and dissemination, and be able to assess their effectiveness in meeting the statistical needs of society.

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MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to State, National and International Statistical System - Role, function and activities of Central and State Statistical Organizations; organization of large scale sample surveys; role of national sample survey organization (NSSO), functions of Ministry of Statistics and Program Implementation (MOSPI).
(20 hrs)

UNIT 2

Vital Statistics: Methods of obtaining vital statistics. Measurement of Fertility- crude birth rate, specific fertility rate. crude death rate, standardized death rates, infant mortality rate, maternal mortality rate, reproduction rate, rate of net migration.
(15 hrs)

UNIT 3

Demographic Methods:- Sources of demographic data - census, register, ad hoc survey, hospital records, demographic profiles of Indian census; life tables, Complete life tables – its main features, mortality rate and probability of dying, use of survival tables.
(20 hrs)

UNIT 4

Index Numbers - Definition- price and quantity relatives, simple and weighted index numbers, methods of constructing simple and weighted index numbers, consumer price index numbers, tests for index numbers, chain based and fixed base index numbers, base shifting. **(20 hrs)**

UNIT 5 (Optional)

History of Indian Statistical system, Indian Statistical Heritage, Indian Statistical Institute, International Statistical Institute, National Statistics Day, International Statistics Day, Indian Statistical Service, Computation of Demographic measures and Vital statistics using R **(15 hrs)**

TEXT BOOKS

1. Gupta, S. C., Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics.*** India: Sultan Chand & Sons.
2. Gupta, S. P. (2011). ***Statistical Methods.*** India: Sultan Chand & Sons.

SUGGESTED READINGS

1. ***Guide to Current Indian Official Statistics***, CSO, Govt. of India, New Delhi.
2. Saluja M.P. (2006). ***Indian Official Statistical Systems***, Statistics Publishing Society, Calcutta
3. Mukhopadhyay, P. (1999). ***Applied statistics***. India: Books and Applied.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VI

A16– DISCIPLINE SPECIFIC CORE COURSE

KU6DSCSTA307: TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSESTA307	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Time Series Analysis is a specialized course that focuses on the analysis and forecasting of time series data. This course covers various methods and techniques used to analyze and model time series data, including exponential smoothing, Box-Jenkins methodology, and estimation of ARMA models. Emphasis is placed on understanding the different components of time series, identifying trends and seasonal fluctuations, and using statistical models for forecasting.

COURSE OBJECTIVES:

- Comprehensive Understanding of Time Series Concepts: Develop a thorough understanding of time series data and its components, including trend, seasonality, and randomness.
- Proficiency in Time Series Modeling Techniques: Master various methods and techniques for analyzing and modeling time series data, including exponential smoothing, Box-Jenkins methodology, and ARMA models.
- Application of Statistical Models for Forecasting: Learn how to apply statistical models and techniques to forecast future values of time series data accurately.
- Evaluation of Model Performance: Acquire skills in evaluating the performance of time series models, including assessing forecasting accuracy and model adequacy.
- Real-world Application of Time Series Analysis: Apply time series analysis techniques to real-world data sets and scenarios, gaining practical experience in analyzing and interpreting time series data.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following:

SL #	Course Outcomes
CO1	Develop a thorough understanding of time series analysis, including its objectives and different components such as trend, seasonality, and noise.
CO2	Proficiency in various exponential smoothing techniques, including single and double exponential smoothing, Holt smoothing, Holt-Winters smoothing, and seasonal smoothing.
CO3	Understand autoregressive (AR), moving average (MA), and autoregressive moving average (ARMA) models, and their applications in time series analysis.
CO4	Estimate time series models using methods such as conditional least squares, conditional maximum likelihood, and the Yule-Walker method.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Time Series Analysis: Introduction to time series, objectives of time series, different components, illustrations, additive and multiplicative decompositions, determination of trend, growth curves, analysis of seasonal fluctuations, autocorrelation function, sample autocorrelation function. **(15 Hours)**

UNIT 2

Exponential Smoothing:, Single and double exponential smoothing, optimal choice of smoothing coefficients and initial values, Holt smoothing, Holt-Winter additive seasonal smoothing, multiplicative seasonal smoothing, adaptive smoothing. Introduction to ETS methodology. **(15 Hours)**

UNIT 3

Introduction to Box-Jenkins Methodology: Stationarity, nonstationarity, Autoregressive (AR) models, Moving Average (MA) models, Autoregressive Moving Average (ARMA) models, stationarity and invertibility conditions of ARMA models, Yule-Walker equations, partial autocorrelation function, Durbin-Levinson algorithm, ACF and PACF of ARMA models, identification of ARMA models.
(15 Hours)

UNIT 4

Estimation of ARMA Models: Conditional least squares, conditional maximum likelihood, Yule –Walker method, model diagnostics using residuals, Portmanteau test, model selection using AIC, BIC, forecasting and measures of forecasting accuracy.
(15 Hours)

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOK

1. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). ***Time Series Analysis: Forecasting and Control (5th Edition).*** John Wiley & Sons.
2. Shumway, R. H., Stoffer, D. S., & Stoffer, D. S. (2017). ***Time Series Analysis and its Applications with R Examples (Vol. 4).*** New York: Springer.

SUGGESTED READINGS

1. Cryer, J. D., Chan, K. S., & Kung-Sik.. Chan. (2008). ***Time Series Analysis: With Applications in R*** **(Vol. 2)**. New York: Springer.
2. Hyndman, R. J., & Athanasopoulos, G. (2018). ***Forecasting: Principles and Practice***. OTexts.
3. Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). ***Forecasting Methods and Applications***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VI

A17– DISCIPLINE SPECIFIC CORE COURSE

KU6DSCSTA308: DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSCSTA308	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Design of Experiments is a foundational course that introduces students to the principles and techniques of designing and analyzing experiments. The course covers basic concepts of experimental design, linear estimation, basic experimental designs, and factorial designs. Emphasis is placed on understanding the principles of randomization, replication, and local control, as well as the analysis of variance (ANOVA) and interpretation of experimental results.

COURSE OBJECTIVES:

- Gain a thorough understanding of the basic principles of experimental design, including randomization, replication, and local control (blocking).
- Develop proficiency in linear estimation techniques and hypothesis testing using ANOVA for one-way and two-way classifications.
- Learn to analyze and interpret results from various basic experimental designs, such as completely randomized design, randomized block design, and factorial designs.
- Acquire skills in comparing treatment effects using ANOVA techniques and performing post-hoc analysis to identify significant differences.
- Apply theoretical knowledge to real-world scenarios through hands-on exercises and projects, gaining practical experience in designing and analyzing experiments.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Develop a thorough understanding of the basic concepts of experiments, the objectives of experimentation, and the principles of experimental design including randomization, replication, and blocking.
CO2	Proficiency in linear estimation, including the estimation space, error space, estimability of parametric functions, and the Best Linear Unbiased Estimator (BLUE) according to the Gauss-Markov theorem.
CO3	Perform analysis of variance for one-way and two-way classification designs with a single observation per cell. They will understand how to partition the total variation
CO4	Apply theoretical knowledge to real-world scenarios through hands-on exercises and projects, gaining practical experience in designing and analyzing experiments.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Basic Concepts: Definition of experiments, objectives of experimentation, principles of experimental design: Randomization, Replication, Local control-Blocking. Types of Experimental Designs, Sources of Variation: Treatment effects, random error, systematic error, experimental error. **(15 Hours)**

UNIT 2

Linear Estimation: Estimation space, error space, estimability of parametric functions and BLUE – Gauss – Markov theorem – Linear hypothesis, Analysis of variance: One way and two way classification (with single observation per cell). **(20 Hours)**

UNIT 3

Basic Designs: Analysis and interpretation of completely randomized design, randomized block design, Latin square design, graeco- Latin design, ANOVA, missing plot technique, estimation of missing observation, comparison of efficiency, relative efficiency, post-hoc analysis. **(20 Hours)**

UNIT 4

Factorial Designs: Basic concepts of factorial experiments, introduction to factorial designs, advantages of factorial designs, two factor factorial designs, interpretation of main effects and interactions, hypothesis testing. **(20 Hours)**

UNIT 5

Optional module: Computational illustration of above concepts using SPSS/R. **(15 Hours)**

TEXT BOOK

1. Gupta, S. C., & Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics***. Sultan Chand & Sons..
2. Montgomery, D. C. (2017). ***Design and Analysis of Experiments***. John wiley & sons.
3. M.N. Das & N. Giri (2017). ***Design of Experiments, Third Edition.*** New Age International

SUGGESTED READINGS

1. D.D. Joshy (1990). ***Linear Estimation and Design of Experiments***, Wiley Eastern.
2. Panneerselvam, R. (2012). ***Design and Analysis of Experiments***. PHI Learning Pvt. Limited, New Delhi.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VI

A11– DISCIPLINE SPECIFIC CORE COURSE

KU6DSCSTA309: STATISTICAL COMPUTING (PRACTICAL)

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSCSTA309	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
	6	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Computing is a practical course. The practical is based on all the courses in the fifth and sixth semesters. The course "Statistical Computing" is designed to provide students with practical experience in applying statistical methods and techniques learned in their fifth and sixth semesters. It serves as a hands-on complement to the theoretical knowledge acquired in previous statistical courses. Through practical exercises and real-world applications, students will develop proficiency in using statistical software tools to analyze data, interpret results, and solve problems encountered in various fields.

COURSE OBJECTIVES:

- Proficiency in Statistical computing: By the end of the course, students should demonstrate proficiency in using statistical software packages such as SPSS, R, or Python for data analysis, manipulation, and visualization.
- Data Management Skills: Students will develop skills in data manipulation and cleaning techniques, including importing, preprocessing, and managing datasets to ensure data quality and integrity.
- Understanding of Descriptive and Inferential Statistics: The course aims to provide students with a solid understanding of descriptive statistics to summarize and visualize data, as well as inferential statistics to make inferences and test hypotheses about populations.
- Ability to Interpret and Communicate Results: Students will learn how to interpret statistical output, draw meaningful conclusions from data analysis, and effectively communicate their findings through written reports, visualizations, and presentations.
- Application of Advanced Statistical Techniques: The course will introduce students to advanced statistical techniques such as Time series analysis, design of experiments, linear regression analysis, Theory of Markov chain and testing of hypotheses, enabling them to apply these methods to analyze complex datasets and solve real-world problems.

COURSE OUTCOME:

After successful completion of this course, students will be able to

SL #	Course Outcomes
CO1	Demonstrate proficiency in using statistical software packages such as SPSS, R, or Python for data analysis, manipulation, and visualization.
CO2	Acquire skills in data preprocessing, including handling missing data, outliers, and data transformation. They will learn data manipulation techniques such as sorting, merging, and reshaping datasets to prepare them for analysis
CO3	Gain competence in applying descriptive and inferential statistical techniques to analyze datasets and draw meaningful conclusions.
CO4	Develop problem-solving skills and critical thinking abilities in the context of statistical analysis. They will learn how to identify appropriate statistical methods for different types of data and research questions, and how to adapt and apply these methods effectively to solve real-world problems.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Markov chain: Computation of transition probability matrix of a Markov chain, properties and classification of states, "markovchain" R package, Creating Markov chain objects, Handling markovchain objects, Markov chain plot with diagram, Conditional distributions, Stationary states, Classification of states, First passage time distributions and means. **(15 Hours)**

UNIT 2

Regression and Testing: Creating a Linear Regression in R, lm function in R, summary and anova, extracting coefficients, standard errors, significance of coefficients, significance of regression, residuals, R squared and adjusted R squared, extracting information measures like AIC and BIC, model selection, prediction, regression through origin. Testing of hypothesis concepts: computation of Type I error, power and power function, plotting power function, empirical size and power calculations. One sample test, two sample tests, Z test, t-test, chi square test, F test.
(25 Hours) **UNIT 3**

Design of experiments and Quality control : One factor design and the ANOVA, notation and terminology, reading data sets into R, the aov() function, summary, boxplot, CRD, RBD, LSD. Quality control using R, the qcr package, control charts in qcr, Process capability analysis, Process capability pl, Estimated process capability plot, **(20 Hours)**

UNIT 4

Time series analysis: Plotting Time Series, plot.ts() function in R, Decomposing Time Series, the decompose() function, Simple Exponential Smoothing, the "HoltWinters()" function in R, forecast package, acf and pacf plots, Holt-Winters Exponential Smoothing, ARIMA Models, simulation of ARMA models, fitting a ARMA model, Selecting a Candidate ARIMA Model, the auto.arima() function, Forecasting Using an ARIMA Model, forecasting accuracy measures.
. **(20 Hours)**

UNIT 5

Optional module: Computational illustration of topics from elective courses. **.** **(15 Hours)**

TEXT BOOKS

1. ***The markovchain Package: A Package for Easily Handling Discrete Markov Chains in R.*** https://cran.r-project.org/web/packages/markovchain/vignettes/an_introduction_to_markovchain_package.pdf
2. Lawson, J. (2014). ***Design and Analysis of Experiments with R***. CRC press.
3. Flores, M., Fernández-Casal, R., Naya, S., & Tarrío-Saavedra, J. (2021). ***Statistical Quality Control with the qcr Package***. *R Journal*, *13*(1), 194-217.
4. Cowpertwait, P. S., & Metcalfe, A. V. (2009). ***Introductory Time Series with R***. Springer Science & Business Media.

SUGGESTED READINGS

1. Hyndman, R. J., & Khandakar, Y. (2008). ***Automatic time series forecasting: the forecast package for R.*** *Journal of statistical software*, *27*, 1-22..

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 4 Credit Practical.

Semester VI

DSE2– DISCIPLINE SPECIFIC CORE COURSE

KU6DSESTA310: STATISTICAL QUALITY CONTROL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSESTA310	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Quality Control (SQC) is a vital discipline that focuses on ensuring the quality of products and processes in various industries. This course provides students with a comprehensive understanding of SQC principles, techniques, and tools, including control charts, process capability analysis, acceptance sampling, and quality improvement methods.

COURSE OBJECTIVES:

- Develop a deep understanding of the principles and concepts of Statistical Quality Control (SQC), including the importance of quality management in various industries and the role of SQC in ensuring product and process quality.
- Master the use of statistical tools and techniques used in SQC, including control charts, process capability analysis, and acceptance sampling, to monitor, analyze, and improve product and process quality.
- Learn how to construct and interpret control charts, including X-bar, R, p, np, and c-charts, to monitor process performance, detect variations, and identify process shifts and trends.
- Acquire skills in assessing process capability using capability indices such as Cp, Cpk, and Cpmk, and understanding the relationship between process capability and specification limits.
- Gain practical knowledge of designing acceptance sampling plans to ensure product quality and minimize risks associated with producer's and consumer's risks.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand the fundamental concepts of quality and its importance in various industries.
CO2	Differentiate between common cause and special cause variation and understand their implications on process performance.
CO3	Interpret control charts effectively, including calculating control limits, identifying control chart patterns, and detecting process shifts and trends.
CO4	Proficiency in using statistical tools such as control charts, process capability analysis, acceptance sampling, and quality improvement techniques.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

UNIT 1

Basic Concepts: Definition of quality, historical perspective of statistical quality control (SQC), importance of SQC in various industries. Types of Variation: Common cause variation, special cause variation, understanding sources of variation. Statistical Tools in SQC: Control charts, process capability analysis, acceptance sampling, quality improvement techniques. **(15 Hours)**

UNIT 2

Introduction to Control Charts: Purpose and benefits, types of control charts , X-bar chart, R chart, p-chart, np-chart, c-chart. Construction and Interpretation of Control Charts: Calculation of control limits, interpretation of control chart patterns, detecting process shifts and trends. Control Chart Selection: Factors influencing control chart selection, considerations for variable and attribute data. **(15 Hours)**

UNIT 3

Process Capability Indices: Definition of process capability indices , Cp, Cpk and Cpmk, interpretation of capability indices, relationship between process capability and specification limits. Process Performance vs. Process Capability: Differentiating between process performance and process capability, practical implications. Assessing Process Capability: Methods for assessing process capability, estimation of process capability indices. **(15 Hours)**

UNIT 4

Introduction to Acceptance Sampling: Purpose of acceptance sampling, types of acceptance sampling plans , single, double and multiple sampling. Sampling Plans and OC Curves:

Operating characteristic (OC) curves, relationship between producer's risk, consumer's risk, and sample size, designing acceptance sampling plans. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. **(15 Hours)**

TEXT BOOK

1. Montgomery, D. C. (2019). ***Introduction to Statistical Quality Control (8th Edition)***. John wiley & sons..
2. Grant,E. L. and Leavenworth, R. S.(2017). ***Statistical Quality Control.*** McGraw Hill.

SUGGESTED READINGS

1. Duncan, A.J.(1986).***Quality Control and Industrial Statistics.*** Wiley
2. Mittage, H.J. and Rinne, H. (1993). ***Statistical Methods for Quality Assurance.*** Chapman and Hall.
3. Oakland,J.S.and Follorwel, R.F.(1990).***Statistical Process Control***. East-West Press.
4. Schilling,E.G.(1982).***Acceptance Sampling in Quality Control***. Marcel Dekker.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VI

DSE2– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA311: STATISTICAL MACHINE LEARNING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSESTA311	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Machine Learning is a rapidly evolving field with applications in various domains such as finance, healthcare, and marketing. This course provides an in-depth exploration of machine learning algorithms and techniques, focusing on both supervised and unsupervised learning methods.

COURSE OBJECTIVES:

- Develop a deep understanding of fundamental concepts, techniques, and algorithms in machine learning, including supervised and unsupervised learning methods.
- Gain proficiency in selecting appropriate machine learning models based on the bias-variance tradeoff and evaluating their performance using various metrics.
- Acquire practical experience in implementing machine learning algorithms using popular tools and libraries such as scikit-learn, TensorFlow, or PyTorch.
- Apply machine learning techniques to real-world datasets and problems across different domains, including classification, regression, and feature extraction.

- Explore advanced topics in machine learning such as nonparametric methods, regularization techniques, and wavelet smoothing, and understand their applications in cutting-edge research and industry.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Apply various machine learning techniques, including supervised and unsupervised learning methods, to analyze and interpret real-world datasets.
CO2	Select appropriate machine learning models based on the characteristics of the data and evaluate their performance using relevant metrics such as accuracy, precision, recall, and F1-score.
CO3	Develop proficiency in implementing machine learning algorithms using programming languages such as Python and utilizing machine learning libraries like scikit-learn, TensorFlow, or PyTorch for model development and evaluation.
CO4	Enhance their critical thinking and problem-solving skills by applying machine learning techniques to solve complex real-world problems across various domains, including healthcare, finance, and marketing.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Variable Types and Terminology: Least Squares and Nearest Neighbours, Local Methods in High Dimension, Supervised Learning and Function Approximation, A Statistical Model for the Joint Distribution of input and output vectors, Function Approximation, Structured Regression Models, Classes of Restricted Estimators: Roughness Penalty and Bayesian Methods, Kernel Methods and Local Regression, Basis Functions and Dictionary Methods. **(15 Hours)**

UNIT 2

Model Selection: The Bias–Variance Tradeoff. Linear Methods for Regression: Least squares, Subset selection, Shrinkage Methods, Methods using derived input directions, Multiple outcome shrinkage and selection, Lasso and related path algorithms. **(15 Hours)**

UNIT 3

Classification: Linear methods for classification using linear regression of an indicator matrix, linear discriminant analysis, logistic regression and separating hyperplanes. Basis expansions and regularizations: Piecewise polynomials and splines, Filtering and feature extraction, smoothing splines, Automatic Selection of the Smoothing Parameters. **(15 Hours)**

UNIT 4

Nonparametric logistic regression, multidimensional splines, regularization and reproducing kernel Hilbert spaces, wavelet smoothing. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. **(15 Hours)**

TEXT BOOK

1. Hastie, T., Tbishirani, R. and Friedman, J. (2017). ***The Elements of Statistical Learning : Data Mining, Inference and Prediction,*** 2nd Edition. Springer, New York.

2. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). ***An Introduction to Statistical Learning with Applications in R.*** Springer, New York.

SUGGESTED READINGS

1. James, G., Witten,D., Tibshirani, R. and Hastie, T. ***Neural Networks and Deep Learning: A Textbook***.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical

Semester VI

DSE2– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU6DSESTA312: STATISTICAL METHODS USING PYTHON

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSESTA312	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course serves as an introduction to Statistical computing using the Python programming language. Students will learn fundamental programming concepts, data structures, control structures, and object-oriented programming principles. Additionally, the course covers basic file handling, exception handling, and introduces students to random number generation and testing techniques.

COURSE OBJECTIVES:

- Develop a foundational understanding of computer programming concepts, including variables, control structures, data types, and modularization, using the Python programming language.
- Attain proficiency in writing and executing Python code to solve basic programming problems, manipulate data, and implement algorithms using fundamental Python syntax and libraries.
- Gain an introduction to object-oriented programming (OOP) principles, including class definition, inheritance, encapsulation, and polymorphism, and understand their application in Python programming.
- Understand error handling and exception mechanisms in Python, and learn how to effectively handle errors and exceptions to write robust and reliable Python code.
- Gain exposure to statistical programming concepts such as random number generation, probability distributions, and simulation techniques, and learn how to implement them using Python for statistical analysis and modeling.

COURSE OUTCOMES

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate a foundational understanding of computer principles, including the relationship between computers and programs, basic principles of computers, file systems, binary computation, and input/output operations.
CO2	Develop proficiency in Python programming by understanding data types, variables, expressions, statements, operators, and control structures such as loops and decision-making constructs.
CO3	Learn modularization techniques, including the use of standard modules, packages, defining classes, and functions.
CO4	Acquire advanced numerical computation skills, including random number generation, testing random number generators, inverse transformation method (ITM), acceptance-rejection method (ARM), and computation of integrals using techniques such as Monte Carlo methods and Gaussian integration.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT I

Introduction - Relationship between computers and programs -- Basic principles of computers -- File systems - Using the Python interpreter - Introduction to binary computation -- Input / Output. Data types and control structures -Operators (unary, arithmetic, etc.) - **(15 Hours)**

UNIT II

Data types, variables, expressions, and statements -Assignment statements - Strings and string operations -- Control Structures: loops and decision. Modularization and Classes -- Standard modules -- Packages -- Defining Classes -- Defining functions -- Functions and arguments (signature) **(20 Hours)**

UNIT III

Exceptions and data structures - Data Structures (array, List, Dictionary) - Error processing - Exception Raising and Handling, Object oriented design - Programming types -Object Oriented Programming -Object Oriented Design. **(20 Hours)**

UNIT IV

Random number generation, testing a random number generator, inverse transformation method (ITM), Quantile function, properties, Acceptance-Rejection method (ARM), Conditional distribution, exponential tilting, ARM based algorithms, Composition and convolution methods, chi-square, t and F-distributions. **(15Hours)**

UNIT V (Teacher Specific Module-Optional)

Computation of integrals, quadrature formula, double integration, Gaussian integration, Monte Carlo methods, expected values and probabilities, Importance Sampling, rare-event simulation, verification of WLLN, CLT and other approximations through simulation. Empirical computation of level of significance and power of tests. **(15 Hours)**

TEXT BOOKS

1. Haslwanter T. (2016). ***An Introduction to Statistics with Python: With Applications in the Life Sciences,*** Springer
2. Kateri, M. and Agresti, A. (2022). ***Foundations of Statistics for Data Scientists***
   With R and Python, Chapman and Hall

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A19– DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA401:MEASURE AND PROBABILITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA401	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a rigorous introduction to measure theory and probability theory, essential foundations for advanced studies in mathematics, statistics, and related fields. Students will explore fundamental concepts such as measure spaces, integration theory, probability spaces, random variables, and expectations.

COURSE OBJECTIVES:

- Develop Understanding of Measure Spaces: Students will develop a comprehensive understanding of measure spaces, including the concepts of σ-fields, measurable sets, and the Lebesgue measure, laying the foundation for rigorous analysis in probability theory.
- Master Integration Theory: Through the study of integration theory, students will become proficient in techniques for integrating functions over measure spaces, including the Lebesgue integral and its properties, enabling them to analyze complex functions in probabilistic contexts.
- Understand Axiomatic Probability: Students will grasp the axiomatic foundations of probability theory, including probability spaces, conditional probability, and independence of events, providing a rigorous framework for analyzing uncertain events and random processes.
- Analyze Random Variables and Expectations: By studying real and vector-valued random

variables, along with their distribution and density functions, students will learn to characterize and analyze uncertainty in probabilistic models, including computing expectations and moments.

- Apply Inequalities and Convergence: Through the study of inequalities such as Jensen's inequality, Markov's inequality, and convergence theorems like the monotone convergence theorem and dominated convergence theorem, students will learn powerful tools for analyzing probabilistic models and deriving results.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand the concepts of measure and probability and their properties.
CO2	Understand convergence of sequence of sets, sequence of measurable functions and sequence of integrals.
CO3	Develop strong problem-solving and analytical skills, enabling them to apply measure-theoretic techniques to solve complex problems in probability theory, statistical inference, and related areas.
CO4	Acquire a high level of mathematical rigor and proficiency in writing formal proofs, allowing them to rigorously analyze and justify mathematical arguments in measure theory and probability theory.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Measure and Measure Space: Class of sets, limits of sequence of sets, fields and σ-fields, minimal σ-fields and Borel field, monotone class. Measurable space, measure, measure space, Lebesgue measure and counting measure, measurable functions and their properties. Limit of a sequence of measurable functions, simple functions, non-negative measurable functions as limit of simple functions. **(15 Hours)**

UNIT 2

Integral: Integral of a simple function, integral of a measurable function. The monotone convergence theorem, Fatou's lemma. Bounded convergence theorem, Lebesgue dominated convergence theorem, normed linear spaces, Lp spaces, Holder's inequality, Minkowski's inequality. **(15 Hours)**

UNIT 3

Axiomatic Approach to Probability: Probability space, conditional probability space, independence of events and sigma fields, Bayes theorem. Real and vector-valued random variables, distribution function, density function and properties, expectation of a random variable and properties. Sequence of random variables and different modes of convergence: in probability, in distribution, in r-th mean and almost sure, their mutual implications. **(15 Hours)**

UNIT 4

Expectation and Inequalities: Expectation of a function of a random variable as Riemann - Stieltjes integral, moments of a random variable. Inequalities involving moments, Cr-inequality, Jensen's inequality, basic inequality, Markov equality and their applications. **(15 Hours)**

UNIT 5

A short review on set theory and real analysis, history on measure and probability. **(15 Hours)**

Books for study

1. Bhat, B.R. (2004). ***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Robert G. Bartle (1995). ***The Elements of Integration and Lebesgue Measure***. John Wiley & Sons, New York.

Reference books

1. Basu, A.K. (1999). ***Measure Theory and Probability***, Prentice-Hall.
2. Billingsley, P. (1986). ***Probability and Measure, Second Edition***, John Wiley.

3. Parthasarathy, K.R. (2005). ***Introduction to Probability and Measure***, Hindustan Book Agency.
4. Royden, H. L. (1988). ***Real Analysis, Third Edition***, MacMillan Publishing Company, New-York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A20– DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA402: MATHEMATICAL METHODS FOR STATISTICS-II

Semester	Course Type	Course Level	Course Code		Credits	Total Hours
7	CORE	400	KU7DSCSTA402		4	75
Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of advanced mathematical topics in analysis, linear algebra, and their applications. Spanning four units, students will delve into fundamental concepts, theoretical frameworks, and practical techniques essential for understanding and solving complex problems in mathematics and related disciplines. Throughout the course, emphasis is placed on theoretical rigor, problem-solving skills, and the application of mathematical concepts to real-world problems in various statistical fields.

COURSE OBJECTIVES:

- Mastering Fundamental Concepts: Gain a deep understanding of fundamental concepts in analysis and linear algebra, including limits, continuity, derivatives, integrals, vector spaces, matrices, and linear transformations.
- Developing Analytical Skills: Enhance analytical skills through rigorous mathematical reasoning, proof techniques, and problem-solving strategies applied to advanced mathematical topics.
- Exploring Advanced Topics: Explore advanced topics such as spectral decomposition, eigenvalue problems, quadratic forms, and special functions, extending the knowledge beyond basic mathematical principles.
- Applying Mathematical Techniques: Apply mathematical techniques and theoretical frameworks to solve complex problems in various domains, including physics, engineering, data science, and optimization.
- Building Theoretical and Practical Competence: Develop both theoretical understanding and practical competence, enabling students to analyze, model, and solve real-world problems using advanced mathematical tools and methodologies.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Demonstrate proficiency in understanding the concepts of limits and continuity of functions in metric spaces.
CO2	Evaluate limits of functions and determine their continuity at various points.
CO3	Develop a strong understanding of the Riemann-Stieltjes integral and its properties, including convergence criteria and applications.
CO4	Gain competence in analyzing sequences and series of functions, including understanding uniform convergence and its implications on continuity, integration, and differentiation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Unit I

Limit and Continuity of Functions: Metric spaces, compact set, perfect set, connected set, limit of functions, continuous function, continuity and compactness, continuity and connectedness, discontinuities, monotone functions, derivative of a real-valued function, mean value theorem. Riemann-Stieltjes integral and properties. **(15 Hours)**

Unit II

Sequence of Functions and Functions of Several Variables: Sequences and series of functions, uniform convergence. Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weierstrass theorem, improper integrals, the Beta and Gamma functions. Functions of several variables, limits and continuity. Taylor's theorem and its applications. Conditions for the optima of multivariate functions.
(15 Hours)

Unit III

Vector Spaces and Matrices: Vector space, subspaces, linear dependence and independence, basis and dimensions, direct sum and complement of a subspace, inner product and orthogonality. Algebra of matrices, linear transformations, different types of matrices. Row and column space of a matrix, inverse of a matrix, rank, factorization of a matrix, elementary operations and reduced forms. **(15 Hours)**

Unit IV

Spectral Decomposition and Quadratic Forms: Eigenvalues and eigenvectors, spectral representation and singular value composition, Cayley-Hamilton theorem, algebraic and geometric multiplicities, Jordan canonical form. Linear equations, generalized inverses and quadratic forms, rank-nullity theorem, generalized inverses, Moore-Penrose inverse, computation of the g-inverse. Quadratic forms, classification of quadratic forms, rank and signature, positive definite and non-negative definite matrices, simultaneous diagonalization of matrices. **(15 Hours)**

Unit V

Computational illustrations of above concepts in R/Mathematica-cloud **(15 Hours)**

Books for Study

1. Rudin, W. (2013). ***Principles of Real Analysis (3rd Ed.)***, McGraw-Hill.
2. Ramachandra Rao and Bhimasankaran (1992). ***Linear Algebra***. Tata McGraw Hill, New-Delhi.
3. Malik, S.C & Arora, S. (2006). ***Mathematical Analysis, Second Edition,*** New Age International Publishers.
4. Mathai, A. M. and Haubold, H. J. (2017). ***Linear Algebra – A Course for Physicists and Engineers***, De Gruyter, Germany.

Reference Books:

1. Apostol, T.M. (1974). ***Mathematical Analysis, Second Edition.*** Narosa, New Delhi.
2. Lewis, D.W. (1995). ***Matrix Theory***, Allied publishers, Bangalore.
3. Mathai, A.M. (1998). ***Linear Algebra Part I, II & III.***, Centre for Mathematical Sciences.
4. Rao C.R. (2002). ***Linear Statistical Inference and Its Applications, Second Edition***, John Wiley and Sons, New York.
5. Seymour Lipschutz, Marc Lipson (2005). ***Schaum's Outline Series - Linear Algebra (3rd edition).*** Tata McGraw Hill.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A21– DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA403: ADVANCED DISTRIBUTION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA403	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers a comprehensive exploration of advanced topics in probability theory and statistical distributions. Through a series of four units, students will delve into the intricacies of generating functions, lifetime distributions, multivariate distributions, non-central distributions, and density estimation techniques. Throughout the course, students will develop a deep understanding of advanced probability and statistical concepts, preparing them to analyze complex datasets and apply sophisticated statistical methods in various fields.

COURSE OBJECTIVES:

- Advanced Understanding of ProbabilityDistributions: Gain a deep understanding of advanced topics in probability theory, including generating functions, multivariate distributions, and non-central distributions.
- Statistical Distributions Mastery: Develop proficiency in analyzing and interpreting various statistical distributions, such as Weibull, Pareto, multivariate normal, and chi-square distributions.
- Quantitative Analysis Skills: Enhance quantitative analysis skills by exploring order statistics, quadratic forms of normal variables.
- Statistical Modeling Competence: Acquire the ability to model and analyze complex datasets using advanced probability and statistical techniques, including compound distributions and mixture distributions.
- Application of Density Estimation Techniques: Learn how to apply non-parametric density estimation techniques, such as kernel density estimation, to analyze and visualize data distributions effectively.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of various probability distributions, including discrete and continuous distributions, and their properties.
CO2	Proficiency in analyzing multivariate distributions, including multinomial and multivariate normal distributions.
CO3	Gain mastery in analyzing lifetime distributions such as Weibull, Pareto, generalized gamma, Gumbel, and extreme value distributions.
CO4	Develop an understanding of non-central distributions including chi-square, t, and F distributions, and their properties.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

COURSE CONTENTS

Unit 1

An overview of generating functions: factorial moment generating function, factorial moments, cumulant generating function, cumulants, relationships between moments and cumulants, power series distributions, generalized power series distribution, compound distributions, compound binomial, compound poisson, truncated distributions, mixture distributions.
(15 Hours)

Unit 2

Lifetime distributions: Weibull, Pareto, generalized gamma, Gumbel, extreme value; Pearson system of curves, properties. Exponential family of distributions, properties; Order statistics, pdf of a single order statistic, joint pdf of k-order statistics, pdf of maximum and minimum order statistics, distribution of median, distribution of range. **(15 Hours)**

Unit 3

Multivariate distributions: Multinomial distributions, multivariate normal distribution (both singular and nonsingular)- characteristic function, marginal and conditional distributions, properties and characterizations, Cramer-Wold theorem, Jacobians of matrix transformations Y= AXB, Y=AXA', X= TT'. Quadratic forms of normal variables and vectors, distribution of quadratic forms in normal variables (both scalar and vector quadratic forms), Cochran's theorem, Independence of quadratic forms.
(15 Hours)

Unit 4

Non-central distributions: Non central chi-square, t, F and their properties, multivariate gamma and beta distributions, Wishart distribution, characteristic function, additive property, distribution of generalized variance.Introduction to non-parametric density estimation, kernel density estimation. **(15 Hours)**

Unit 5 (Optional)

Review of univariate discrete and continuous distributions. Bivariate exponential distribution of Marshall and Olkin - marginal distribution, characteristic function and lack of memory property. **(15 Hours)**

TEXT BOOKS

1. Anderson, T.W. (2003): ***Multivariate Analysis.*** John-Wiley, New York.
2. Rohatgi, V.K. (2001). ***An Introduction to Probability and Statistics***, 2nd Edition. John Wiley and Sons.
3. Krishnamurthy, K. (2006). ***Handbook of Statistical Distributions with Applications***. Chapman & Hall/CRC, New York.

Reference books

1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995). ***Continuous Univariate Distributions, Vol. I & Vol. II***, John Wiley and Sons, New York.
2. Johnson, N.L., Kotz. S. and Kemp. A.W. (1992). ***Univariate Discrete Distributions***, John Wiley and Sons, New York.
3. Stuart, A. Ord, A. (1994). ***Kendall's Advanced Theory of Statistics, Distribution Theory, 6th Edition***. Wiley-Blackwell.
4. Gupta, S.C. and Kapoor, V.K. (2000). ***Fundamentals of Mathematical Statistics, 10th Revised Edition.*** Sultan Chand & Sons, New Delhi.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to Section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A22– DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA404: STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA404	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers a comprehensive exploration of advanced topics in statistical theory and methodology, providing students with a solid foundation in estimation and hypothesis testing techniques. Through a series of four units, students will delve into key concepts such as sufficiency, completeness, and minimum variance unbiased estimation, gaining a deep understanding of the theoretical underpinnings of estimation theory. Overall, this course aims to provide students with the knowledge and skills necessary to tackle complex statistical problems, equipping them with the tools to make informed decisions based on data analysis and hypothesis testing.

COURSE OBJECTIVES:

- Develop a deep understanding of advanced topics in statistical theory, including sufficiency, completeness, and minimum variance unbiased estimation.
- Gain proficiency in estimation techniques such as method of moments, method of maximum likelihood, and minimum chi square method, and understand their theoretical underpinnings.

- Acquire practical skills in statistical testing methodologies, including Neyman-Pearson lemma, most powerful tests, likelihood ratio tests, and sequential probability ratio tests (SPRT).
- Learn how to design and conduct statistical tests effectively, considering factors such as level of significance, power function, and nuisance parameters.
- Apply theoretical knowledge to real-world statistical problems, developing the ability to make informed decisions based on data analysis and hypothesis testing.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Mastery of advanced statistical concepts: Students will demonstrate a thorough understanding of advanced statistical theories, including sufficiency, completeness, and minimum variance unbiased estimation, and their applications in real-world scenarios.
CO2	Proficiency in estimation techniques: Students will be proficient in employing various estimation methods such as method of moments, method of maximum likelihood, and minimum chi square method, and applying them effectively to estimate parameters from data.
CO3	Competence in statistical testing methodologies: Students will develop competence in statistical testing methodologies, including Neyman-Pearson lemma, likelihood ratio tests, and sequential probability ratio tests, and will be able to apply these techniques to test hypotheses and draw meaningful conclusions.
CO4	Ability to design and conduct statistical experiments: Students will acquire the skills necessary to design and conduct statistical experiments effectively, considering factors such as level of significance, power function, and nuisance parameters, and will be able to interpret and analyze the results accurately.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Sufficiency and Completeness: A brief review on properties of estimators, consistent asymptotically normal (CAN) estimators, efficiency, sufficiency, Fisher-Neymann factorization theorem for sufficiency (proof for discrete distributions only), joint sufficient statistics, minimal and complete sufficient statistics, ancillary statistics, Basu's theorem, examples. **(15 hours)**

UNIT 2

Minimum Variance Unbiased Estimation: Minimum variance unbiased estimator (MVUE), Likelihood and score functions. Fisher information, Cramer–Rao Lower Bound (CRLB), Minimum variance bound d estimator (MVB), uniformly minimum variance unbiased estimator (UMVUE), Rao-Blackwell and Lehmann-Scheffe theorems. Method of moments and method of maximum likelihood, maximum likelihood estimator (MLE) and its asymptotic properties. Method of minimum chi square and method of modified minimum chi square. **(25 hours)**

UNIT 3

Neyman-Perason Lemma and Most Powerful Tests: p-value, level of significance and size of test, power function, Neymann-Pearson lemma, most powerful (MP) and uniformly most powerful (UMP) tests. Monotone likelihood ratio (MLR) and UMP tests, unbiased tests, uniformly most powerful unbiased (UMPU) tests, testing in the presence of nuisance parameters, similar test,, alpha similar tests, Neymann structure, problems. **(20 hours)**

UNIT 4

Likelihood Ratio Test and SPRT : Likelihood ratio test, monotone likelihood ratio property, asymptotic distribution of LRT statistic, sequential testing, sequential probability ratio test, properties, introduction of non-parametric tests and confidence interval estimation, connection between confidence interval estimation and testing of hypotheses. **(20 hours)**

UNIT 5(Teacher Specific Module-Optional)

History of estimation and testing, illustration of the concepts in unit 1 to 4 using R, use of special R packages for the computation of MLE, non parametric tests and confidence intervals. **(10 hours)**

Text Books

1. Casella,G.and Berger, R.L. (2002). ***Statistical Inference, SecondEdition***, Duxbury, Australia.
2. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). ***An Introduction to Probability and Statistics,3rd Edition,*** John Wiley and Sons, NewYork.
3. Kale, B. K. (2005). ***A First Course on Parametric Inference***. Alpha Science Int'l Ltd.

Reference Books

1. Lehman, E. L. (1986):***Testing of Statistical Hypotheses***. John Wiley, New York.
2. Lehmann, E. L(1983). ***Theory of Point Estimation***, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A19-DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA405:MATHEMATICAL METHODS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA405	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4		1	50	50	100	3(T)

COURSE DESCRIPTION

This course provides a rigorous treatment of advanced mathematical methods essential for understanding and solving complex problems in various fields such as mathematics, physics, engineering, and computer science. The course covers topics including sequences, series, convergence, functions of several variables, linear algebra, and quadratic forms.

COURSE OBJECTIVES:

- Understand the concepts of limit and continuity of functions and their properties
- Understand convergence of sequences and series of real numbers and functions.
- Understand the vector space, matrices and its properties
- Understand the properties of quadratic forms and its reduction.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understand and apply various tests for convergence of sequences and series.
CO2	Understand and apply the beta and gamma functions along with their properties and applications.
CO3	Develop a strong foundation in linear algebra, including vector spaces, subspaces, linear dependence and independence, basis and dimensions, matrices and determinants.
CO4	Acquire proficiency in eigenvalues and eigenvectors, spectral decomposition, algebraic and geometric multiplicities.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Sequences, series and their convergence, limit superior, limit inferior, limit of sequences, Cauchy sequence. Comparison test, D'Alembert's ratio test, Cauchy's root test, Raabi's test, Gauss test, Cauchy's integral test, Absolute convergence of series, Leibnitz's test for the convergence of alternating series, conditional convergence, indeterminate form, L'Hospital 's rule (problems only).
(**20 Hours**)

UNIT 2

The beta and gamma functions, duplication formula for gamma function, incomplete beta and gamma functions, functions of several variables, Limits and continuity, Taylor's theorem and its applications, Conditions for the optima of multivariate functions, Lagrange's method for constrained optimum, examples (bivariate case only) (**20 Hours**)

UNIT 3

Vector space, Subspaces, Linear dependence and independence, Basis and dimensions, Matrices and determinants, symmetric, orthogonal and idempotent matrices, Row and column space of matrix, Rank, inverse, Characteristic polynomial, Cayley-Hamilton Theorem (statement and problem).
(**15 Hours**)

UNIT 4

Eigen values and eigen vectors, Spectral decomposition, Algebraic and geometric multiplicities, Generalized inverse, Quadratic forms, Classification of quadratic forms, Properties and reductions. **(15 Hours)**

UNIT 5

Introduction to set theory, limit point of a set, closed, countable and uncountable sets. **(5 Hours)**

TEXT BOOKS

1. Malik, S.C & Arora, S. (2006). ***Mathematical Analysis, Second Edition,*** New-age international publishers.
2. Mathai, A. M. & Haubold, H. J. (2017). ***Linear Algebra – A course for Physicists and Engineers,*** De Gruyter, Germany.

SUGGESTED READINGS

1. Rudin, W. (2013). ***Principles of Real Analysis, (3rdEd.)***. McGraw Hill.
2. Ramachandra Rao and Bhimasankaran (1992). ***Linear Algebra.*** Tata McGraw Hill, New Delhi.
3. Apostol, T. M. (1974). ***Mathematical Analysis, Second Edition***. Narosa, New Delhi.
4. Rao, C. R. (2002). **Linear Statistical Inference and Its Applications**, Second Edition, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A20-DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA406: PROBABILITY AND DISTRIBUTION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA406	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive understanding of probability theory and statistical distributions, covering both discrete and continuous random variables. Students will learn the fundamental concepts of probability, random variables, distribution functions, and moments, along with their applications in various fields including biostatistics. Additionally, the course explores different modes of convergence of random variables and their significance in statistical inference.

COURSE OBJECTIVES:

- Understand the concepts of probability and properties.
- Understand characteristic function and its properties.
- Understand various laws of large numbers and central limit theorems.
- Understand the concepts of discrete and continuous distributions.
- Understand the normal distribution and various non-normal distributions, their properties and applications for scientific research.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Understand various discrete probability distributions.
CO2	Develop a strong grasp of continuous probability distributions.
CO3	Comprehend the various modes of convergence of sequences of random variables and their definitions.
CO4	Learn about moment generating functions and their limitations, as well as characteristic functions and their elementary properties.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Computation of probability based on classical and empirical definitions: Axiomatic approach to probability, probability space, conditional probability space, independence of events, Bayes' theorem and examples, random variable, distribution function, density function, expectation, variance and moments of a random variable and properties. (**20 Hours**)

UNIT 2

Definition of moment generating function and its limitations: characteristic function, elementary properties, characteristic functions and moments. Sequence of random variables, various modes of convergence of sequence random variables (definition only), Weak law of large numbers, strong law of large numbers, central limit theorem, DeMoivre-Laplace and Lindbergh- Levy forms of CLT. Applications of CLT in biostatistics. (**20 Hours**)

UNIT 3

Discrete distributions: Discrete Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative binomial, Hyper geometric, Multinomial. Properties of these distributions. Sample simulation and fitting of discrete distributions. (**20 Hours**)

UNIT 4

Continuous distributions: Continuous Uniform, Exponential, Beta, Gamma, Normal, Weibull, Pareto, Laplace, Logistic, Cauchy and log-normal distributions. Properties of these distributions. Sample simulation and fitting of continuous distributions. (**20 Hours**)

UNIT 5

Revisit to distribution function, discrete random variable, probability mass function, continuous random variable, probability density function. Simulation from standard distributions. (**10 Hours**)

TEXT BOOKS

1. Krishnamurthy, K.(2006). ***Handbook of Statistical Distributions with Applications*** .Chapman & Hall/CRC, New-York.
2. Schinazi, R.B. (2010). ***Probability with Statistical Applications*** *Second Ed* . Springer, New York.

SUGGESTED READINGS

1. Bhat, B.R. (2004). ***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Rohatgi, V. K. (2020). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern
3. Johnson, N.L., Kotz, S.and Balakrishnan, N. (1995). ***Continuous Univariate Distributions****, Vol. I & Vol. II,* John Wiley and Sons, New-York.
4. Johnson, N.L., Kotz. S. and Kemp. A.W.(1992). ***Univariate Discrete Distributions,*** John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A21-DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA407-ANALYSIS OF CLINICAL TRIALS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA407	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of the fundamental principles and methodologies involved in designing, conducting, and analyzing clinical trials. It delves into the ethical considerations, protocol development, data management, and statistical techniques essential for the successful implementation of clinical research studies.

OURSE OBJECTIVES:

- Understand the importance and ethical considerations of clinical trials in medical research.
- Describe the different phases of clinical trials and their purposes.
- Calculate sample sizes for one-sample and two-sample cases in comparative trials and activity studies.
- Define and understand the goals of meta-analysis in clinical trials

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Comprehensive understanding of clinical trials, including their introduction, the necessity and ethical considerations, identification of bias and random errors, protocol development, conduct, and an overview of phases I-IV trials.
CO2	Acquire the ability to determine sample sizes in one and two-sample cases for comparative trials, activity studies, testing, and other purposes.
CO3	Gain proficiency in meta-analysis in clinical trials, understanding its concept, goals, and approaches including fixed and random effect approaches.
CO4	Develop practical skills in applying principles learned in clinical trial design, sample size determination, surrogate endpoint selection, and meta-analysis to real-world scenarios.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, Protocols, conduct of clinical trials, overview of Phase I-IV trials, Data management-data definitions, standard operating procedure, informed consent form, case report forms, database design, data collection systems for good clinical practice. (**15 Hours**)

UNT 2

Design of clinical trials: Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization. Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs, Zelen's designs, design of bioequivalence trials. Outcome measures.

(**15 Hours**)

UNIT 3

Sample size determination in one and two sample cases: comparative trials, activity studies, testing and other purposes, unequal sample sizes and case of ANOVA. Surrogate endpoints-selection and design of trials with surrogate, analysis of surrogate end point data. Reporting and analysis-Interpretation of result, multi-center trials. (**15 Hours**)

UNIT 4

Meta analysis in clinical trials: concept and goals, fixed and random effect approaches. Bioassay: Direct and indirect assays, Quantal and quantitative assays, Parallel line and slope ratio assays, Design of bioassays. (**10 Hours**)

UNIT 5

Review of basic designs in clinical trials. **(5 Hours)**

TEXT BOOKS

1. Chen, D.G. and Peace, K.E. (2011). ***Clinical Trial Data Analysis Using R***. Chapman & Hall
2. Friedman, L. M., Furburg, C. D. Demets, L. (1998): ***Fundamentals of Clinical Trials***, Springer Verlag.
3. Kulinskaya E, Morgeathaler S, Staudte R G(2008). ***Meta analysis***, Wiley.

SUGGESTED READINGS

1. Das, M. N. and Giri(2008). ***Design of Experiments***, New Age, India.
2. Turnbull (1999*): **Group Sequential Methods with Applications to Clinical Trails,*** CRC Press.

TEACHING LEARNING STRATEGIES

Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

A22 -DISCIPLINE SPECIFIC CORE COURSE

KU7DSCSTA408 - BIOSTATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCSTA408	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of the fundamental concepts and methodologies in statistical estimation and hypothesis testing. Students will gain a comprehensive understanding of the properties of estimators, minimum variance unbiased estimation, tests of hypotheses, and parametric tests.

COURSE OBJECTIVES:

- Understand the concepts of Sufficiency and Completeness
- Understand the concepts of Minimum Variance Unbiased Estimation.
- Understand various estimation methods and applications in real life problems.
- Apply various parametric and sequential testing procedures to deal with real life problems.
- Understand Most Powerful Tests for testing simple null hypothesis and developing MP tests for different problems.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	A thorough understanding of important properties of estimators of a parameter such as sufficiency, consistency, unbiasedness and efficiency.
CO2	Understanding the notion of Fisher-Neyman factorization theorem for sufficiency,minimal and complete sufficient statistics.
CO3	Derivation of the Cramer-Rao lower bound and the conditions for the existence of MVB estimator, apply the concept of Rao-Blackwell and Lehmann-Scheffe theorems to obtain UMVUE of a parameter.
CO4	To introduce the concept of testing of hypothesis, critical region, significance level, power of the test and p-value.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Sufficiency, Ancillary Statistic and Completeness: A brief review on properties of estimators, consistent asymptotically normal (CAN) estimators and their properties, sufficiency, minimal sufficiency Fisher-Neymann factorization theorem for sufficiency (proof for discrete distributions only), joint sufficient statistics, complete sufficient statistic, ancillary statistic and Basu's theorem.

(**15 Hours**)

UNIT 2

Minimum Variance Unbiased Estimation: Minimum variance unbiased estimator (MVUE), Likelihood and score functions. Fisher information, Cramer–Rao Lower Bound (CRLB), Minimum variance bound unbiased estimator (MVB). uniformly minimum variance unbiased estimator (UMVUE), Rao-Blackwell and Lehmann-Scheffe theorems. Method of moments and method of maximum likelihood and asymptotic properties of MLE.

(**25 Hours**)

UNIT 3

Neyman-Perason Lemma and Most Powerful Tests: p-value, level of significance and size of test, power function, Neymann-Pearson lemma, most powerful (MP) and uniformly most powerful

(UMP) tests. Monotone likelihood ratio (MLR) and UMP tests, unbiased tests, uniformly most powerful unbiased (UMPU) tests, testing in the presence of nuisance parameters, similar test,, alpha similar tests, Neymann structure, problems. **(20 Hours)**

UNIT 4

Likelihood Ratio Test and SPRT : Likelihood ratio test, monotone likelihood ratio property, asymptotic distribution of LRT statistic, sequential testing, sequential probability ratio test, properties, introduction of non-parametric tests and confidence interval estimation, connection between confidence interval estimation and testing of hypotheses. **(20 Hours)**

UNIT 5

History of estimation and testing, illustration of the concepts in unit 1 to 4 using R, use of special R packages for the computation of MLE, non parametric tests and confidence intervals, applications in biostatistics.

(10 Hours)

TEXT BOOKS

1. Hogg, R. V., McKean, J. W., & Craig, A. T. (2013). ***Introduction to Mathematical Statistics***. Pearson Education India.
2. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). ***An Introduction to Probability and Statistics***,3rd Edition, John Wiley and Sons, NewYork.
3. Mood, A. M., & Graybill, F. A. (6). Boes, DC (1974). ***Introduction to the Theory of Statistics***.Third edition. McGraw Hill.

SUGGESTED READINGS

1. Casella,G.andBerger,R.L.(2002).***Statistical Inference***,SecondEdition,Duxbury,Australia.
2. Lehman, E. L. (1986):***Testing of Statistical Hypotheses***. John Wiley, New York.
3. Lehmann, E. L(1983). ***Theory of Point Estimation***, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

SEMESTER VII

DSE3– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU7DSESTA409: APPLIED REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSESTA409	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive understanding of regression analysis techniques, ranging from multiple linear regression models to non-linear regression methods. Students will learn how to apply these techniques to real-world datasets and interpret the results effectively. Through hands-on exercises and case studies, participants will gain practical skills in regression analysis and model diagnostics.

COURSE OBJECTIVES:

- Understand the fundamental principles and assumptions underlying multiple linear regression models.
- Learn to apply Ordinary Least Squares (OLS) and Maximum Likelihood (ML) estimators in regression analysis.
- Develop proficiency in diagnosing and addressing common issues in regression models, such as multicollinearity, heteroscedasticity, and autocorrelation.
- Acquire knowledge of nonparametric regression techniques, including polynomial regression and spline smoothing, and their applications.
- Gain insight into non-linear regression methods, such as Generalized Linear Models (GLM), logistic regression, and Poisson regression, and their interpretation and model selection criteria.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Understanding and applying multiple linear regression models and also estimating parameters using least square estimation, assessing statistical assumptions, and interpreting the properties of estimators.
CO2	Concepts and techniques of multiple regression analysis along with addressing issues such as multicollinearity, heteroscedasticity, and autocorrelation, including detection and remedial measures.
CO3	Nonparametric regression techniques and spline smoothing methods.
CO4	Generalized linear models, with a focus on logistic regression and Poisson regression and their applications.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

Unit 1

Multiple Linear Regression Models: Multiple regression models, OLS and ML estimators, statistical assumptions and properties of estimators, standard error of estimates, tests of significance and confidence intervals for the parameters, error and residual plots. **(15 Hours)**

Unit 2

Model Diagnostics: Multicollinearity, heteroscedasticity, autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them. Tests for autocorrelation, Durbin-Watson test, outliers and influential points, robust estimation, indicator variables as regressors, model selection. **(25 Hours)**

Unit 3

Nonparametric Regression: Polynomial regression in one and several variables, estimation and order selection, Nonparametric regressions and concept of spline smoothing. Kernel density regression, Nataray -Watson estimation, Diagnostic checks and correction. **(15 Hours)**

Unit 4

Non-Linear Regression: Linearization transforms, Generalized linear models (GLM), logistic regression, Poisson regression, maximum likelihood estimation of GLM, model selection, deviance and deviance information criterion, residuals and cox-snell residuals,

interpretation of coefficients in logistic regression.
(15 Hours)

Unit 5

Fitting regression model using R/SPSS/SAS

Books for Study:

1. Draper, N.R. and Smith, H. (1998): ***Applied Regression Analysis, 3rd Ed***. John Wiley.
2. Gujarati, D.N. (2007): ***Basic Econometrics (Fourth Edition)***, McGraw-Hill, New York.
3. Montgomery, D.C, Peek, E.A. and Vining, G.G. (2006): ***Introduction to Linear Regression Analysis,*** John Wiley.

Reference Books:

1. Seber, G.A.F. and Lee, A.J. (2003): ***Linear Regression Analysis***, Wiley
2. Johnston, J. (1984): ***Econometric Methods, 3rd ed.***, McGraw Hill, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct class room, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

DSE– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU7DSESTA410: DATA VISUALISATION AND ANALYSIS USING PYTHON

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSESTA410	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course aims to build statistical knowledge from the ground up by enabling the learner to understand the ideas behind inferential statistics and begin to formulate hypotheses that form the foundations for the applications and algorithms in statistical analysis, business analytics, machine learning, and applied machine learning. This course begins with the basics of programming in Python and data analysis, to help construct a solid basis in statistical methods and hypothesis testing, which are useful in many modern applications. This course is intended to serve as a bridge in statistics for graduates and business practitioners interested in using their skills in the area of data science and analytics as well as statistical analysis in general.

COURSE OBJECTIVES:

- Develop a solid foundation in Python programming language, including understanding data types, collections, logic, and control flow structures.
- Gain proficiency in creating and organizing reusable code through functions, scripts, and modules.
- Acquire skills in utilizing numerical and scientific Python libraries like NumPy and SciPy for mathematical and scientific computations.
- Master the art of data visualization by learning various techniques to represent statistical quantities, including textual, tabular, and graphical methods.

- Explore different visualization libraries such as matplotlib, pandas, seaborn, bokeh, and plotly to create a wide range of charts and visualizations.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Proficiency in Python Programming: Students will demonstrate proficiency in Python programming, including understanding basic syntax, data types, control flow structures, and functions, enabling them to solve computational problems efficiently.
CO2	Manipulate and analyze data effectively using Python, including handling different data types, collections, and utilizing libraries such as NumPy, SciPy, and pandas for numerical and scientific computing tasks.
CO3	Develop competence in data visualization techniques, including creating various types of plots and charts using libraries like matplotlib, seaborn, bokeh, and plotly, and effectively presenting data insights through graphical representations.
CO4	Acquire proficiency in conducting descriptive statistical analysis, including calculating measures of central tendency, dispersion, and performing hypothesis testing, enabling them to derive meaningful insights and make informed decisions based on data analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit 1

Introduction to Python programming, Starting Up with Python, scripting and interacting, Jupyter notebook, types in python, collections in python, logic and control flow, functions, scripts, modules, numerical python-Numpy, Scientific python-SciPy, panel data-pandas.
(15 Hours)

Unit 2

Data visualization: presenting statistical quantities, textual presentation, tabular presentation, graphical presentation, design and visual representation, plotting and visualising-mathplotlib, plotting functions, line style and colors, titles and labels, grids, multiple plots, sub plots, plotting surfaces. **(20 Hours)**

Unit 3

Creating charts, data visualisation with pandas, seaborn, bokeh, plotly, scatterplot, line chart, barchart, pie chart, histogram, box plot, area plot, heatmap, examples.
(15 Hours)

Unit 4

Descriptive statistics: central tendency, measures of dispersion, probability distributions, hypothesis testing and confidence interval, normality test, chi square test, analysis of variance, pearson correlation, examples. **(20 Hours)**

Unit 5 (Teacher Specific Module-Optional)

Practical lab session **(20 Hours)**

Text Books:

1. Rogel-Salazar, J. (2023). ***Statistics and Data Visualisation with Python***. Chapman and Hall/CRC.

Reference Books:

1. McKinney, W. (2022). ***Python for Data Analysis***. " O'Reilly Media, Inc."

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU7DSESTA411:DEMOGRAPHIC STUDIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSESTA41 1	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of demographic concepts, measures, and methods used in the analysis of population dynamics. Students will learn about the sources of demographic data, mortality and fertility measures, population growth indicators, and concepts related to mobility and migration.

COURSE OBJECTIVES:

- Understand the field of demography and its significance in understanding population dynamics.
- Define mortality statistics and their importance in demographic analysis.
- Understand the measurement of population growth using Pearl's vital index, gross reproductive rate (GRR), and net reproductive rate (NRR).
- Define mobility and migration and differentiate between different types of migration.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Identify the various sources of demographic data and their respective strengths and limitations.
CO2	Calculate and interpret mortality measures including crude death rate, age-specific death rates, and infant mortality rate.
CO3	Construct and analyze life tables, including complete and abridged life tables.
CO4	Explain migration models and their applications in demographic analysis.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Demography, Definition and uses of demographic data, Source of vital statistics: Census method-Registration method, Sources of demography data: secondary sources - SRS– surveys. (**15 Hours**)

UNIT 2

Mortality and Fertility: Nature and uses of mortality statistics, Mortality measures: Crude death rate (CDR) and Age-specific death rates (ASDR), Infant mortality rate(IMR), Fertility measures: Basic terms and concepts used in the study of fertility, Measures of fertility: Crude birth rate(CBR), Age specific fertility rate (ASFR), General fertility rate (GFR), Total fertility rate (TFR). (**15 Hours**)

UNIT 3

Measurement of Population Growth: Pearl's vital index, Gross reproductive rate (GRR) and Net reproductive rate (NRR). Life table: Description of life table, construction of complete and abridged life tables, uses of life table. (**15 Hours**)

UNIT 4

Concept of mobility and migration, types of migration, internal migration and its measurement, migration models, concept of international migration. Net-migration. International and postcensal estimates. Projection method including logistic curve fitting.Decennial population census in India. (**15 Hours**).

TEXT BOOKS

1. Goon A.M., Gupta M. K., Dasgupta B. (2008): ***Fundamentals of Statistics***, Published by Prentice Hall, 2nd edition.
2. Gupta S.C. and Kapoor V.K. (2000): ***Fundamentals of Mathematical Statistics***, Sultan Chand Sons 10th edition.

SUGGESTED READINGS

1. Pathak, K.B. and Ram F. (1998): ***Techniques of Demographic Analysis***, Mumbai, Himalaya Publishing House.
2. Shrivastava O.S. (1995): ***Demography and population Studies***, Vikas Publishing house private limited, 2nd edition.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU7DSESTA412:BIOSTATISTICAL COMPUTING USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSESTA412	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
-	6	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of biostatistical concepts and methodologies using the R programming language. Students will develop practical skills in data manipulation, analysis, and visualization, specifically tailored for applications in biomedical research.

COURSE OBJECTIVES:

- Understand various built in functions in R programming for biostatistical data analysis.
- Understand different functions in R programming for writing compute R programmes and develop computer programmes for different problems
- Understand the usage of packages in R for drawing various diagrams and computing descriptive statistics, comparison of means, ANOVA, non-parametric tests, simple correlation and regression procedures

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Define the basic concepts of R software and R packages
CO2	Describe various concepts required for developing the R Language
CO3	Illustrate different R-Graphics facilities
CO4	Describe different sampling methods using R software

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Basic Concepts of R Programming: Introduction to R- Objects and their classes, operators, vectors and matrices, list and data frames, indexing and accessing data, importing and exporting data. Common built-in functions, R-Graphics. **(20 Hours)**

UNIT 2

Matrices and Standard Probability Distributions: Matrices, rank, determinants and inverse. Eigen values and vectors, power of matrices, g-inverse, system of linear equations, roots of algebraic and transcendental equations. Plotting of cdf and pdf of standard distributions. Generations of random samples from standard distributions, demonstrations of the sampling distributions. **(20 Hours)**

UNIT 3

Biostatistical Sampling Methods: Random samples elections, estimation of mean proportion, variance, confidence interval and efficiency under SRS, stratified random sampling, Various kind of allocation, stratification, estimators based on ratio and regression methods pps sampling, two stage cluster sampling, and systematic sampling. **(20 Hours)**

UNIT 4

Biostatistical data analysis: Measures of Morbidity and Mortality in R, Relative Risk, Odds and Odds Ratio, Generalized Odds for Ordered 2 x k Table, Mantel–Haenszel Method, Box Plots, Estimation of Proportions and Odds Ratios, testing of hypotheses. **(20 Hours)**

UNIT 5 (Teacher Specific Module-Optional)

Advanced computing **(20 Hours)**

TEXT BOOKS

1. Maria D.U., Ana F.M. and Alan T.A. (2008*): **Probability and Statistics with R***. CRC Press.
2. Dalgaard, P. (2008): ***Introductory Statistics with R**, (Second Edition),* Springer.

SUGGESTED READINGS

1. Purohit, S.G, Ghore, S.D and Deshmukh, S.R. (2004): ***Statistics Using R***. Narosa.

2. Babak Shahbaba. (2012). ***Biostatistics with R: An Introduction to Statistics through Biological Data***. Springer New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU7DSESTA413:BIOSTATISTICAL COMPUTING USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSESTA413	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
-	6	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of statistical analysis using the Statistical Package for the Social Sciences (SPSS). Students will learn how to navigate the SPSS environment, perform basic and advanced statistical analyses, and interpret the results. Practical exercises and real-world applications will be emphasized to enhance students' proficiency in using SPSS for data analysis.

COURSE OBJECTIVES:

- The main focus of the course will be on to solve biostatistical research question using SPSS
- Illustrate different toolboxes in SPSS
- Data definition and access and data analysis and presentation.
- Apply SPSS software to develop different statistical tools
- Students get awareness to chose appropriate statistical technique and interpret results using SPSS.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Build capacity to analyzing complex information with the help of SPSS.
CO2	Summarize variables using frequencies and descriptive analysis.
CO3	Producing cross tabulation tables and testing for significant relationships with chi square test.
CO4	Understand the usage of assessing relationships between continuous variables through plots and correlations.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

SPSS Environment, Basic Concepts of SPSS Programming: Introduction to SPSS- Starting SPSS, Working with data file, SPSS windows, Menus, Dialogue boxes. Preparing the Data file, Creating data file and entering data, Defining the variables, Entering data, modifying data file, import file. Variable types in SPSS and Defining variables – Creating a Codebook in SPSS. Screening and cleaning data, Manipulation of data. **(20 Hours)**

UNIT 2

Preliminary Analysis in SPSS: Computing Variables- Recoding (Transforming) Variables: Recoding Categorical String Variables using Automatic Recode - Sorting Data - Grouping or Splitting Data. Categorical variables, continuous variables. The Explore procedure - Frequencies Procedure – Descriptive - Compare Means - Frequencies for Categorical Data, different statistical distributions. **(25 Hours)**

UNIT 3

Inferential Statistics: Pearson Correlation, Chi-square Test of Independence – Inferential Statistics for Comparing Means: One Sample t Test, Paired Samples T Test, Independent Samples T Test, One-Way ANOVA. Two way ANOVA, Multivariate ANOVA. **(25 Hours)**

UNIT 4

Non-Parametric statistics: Independent Chi square Test, Mann- Whitney test , Wilcoxon signed rank test, Kruskal- Wallis test. Interpreting the output of tests, p-value computation. **(20 Hours)**

UNIT 5 (Teacher Specific Module-Optional)

Advanced computing **(20 Hours)**

TEXT BOOKS

1. Hinton, P. R., Brownlow, C, Mc Murray, I. and Cozens, B. (2004): ***SPSS Explained,*** Routledge, Taylor and Francis group, New York.

SUGGESTED READINGS

1. Field, A. (2011); ***Discovering Statistics Using SPSS,*** Sage Publications.
2. William E. Wagner. (2015). ***Using IBM SPSS statistics for research methods and social science statistics***, Fifth edition, SAGE Publications, Inc.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

A23– DISCIPLINE SPECIFIC CORE COURSE

KU8DSCSTA401: ADVANCED PROBABILITY THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU8DSCSTA401	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of advanced topics in measure theory and probability theory, focusing on key concepts and theorems fundamental to understanding probability distributions and their properties. Throughout the course, emphasis is placed on developing students' analytical and problem-solving skills through theoretical discussions, practical applications, and examples.

COURSE OBJECTIVES:

- Mastery of Measure Theory Fundamentals: Develop a deep understanding of measure theory concepts, including signed measure spaces, singular and absolutely continuous measures, and key theorems such as the Radon-Nikodym theorem and its applications.
- Proficiency in Probability Theory: Gain proficiency in probability theory, focusing on advanced topics such as characteristic functions, moments, and theorems like Bochner's theorem, enabling students to analyze and understand complex probability distributions.
- Understanding of Law of Large Numbers and Independence: Explore the principles of the Law of Large Numbers, including weak and strong forms, and Kolmogorov's three series theorem, along with their practical applications. Understand the concepts of independence of classes of events and random variables, and apply them in various contexts.
- Application of Central Limit Theorems: Understand and apply central limit theorems, including Lindberg-Levy, Liapounov, and Lindberg-Feller, to analyze the behavior of sums of random variables. Gain insights into their implications and practical applications in statistical inference.
- Development of Analytical and Problem-Solving Skills: Enhance analytical and problem-solving skills through theoretical discussions, proofs, and practical examples. Develop the ability to critically analyze complex mathematical concepts and apply them to solve real-world problems in probability theory and measure theory.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate an advanced understanding of measure theory fundamentals, including signed measure spaces, decomposition theorems, and the Radon-Nikodym theorem, enabling them to analyze and characterize complex measures.
CO2	Proficiency in probability analysis, including the interpretation of characteristic functions, moments, and the application of theorems such as Bochner's theorem, facilitating their ability to analyze and model complex probability distributions.
CO3	Apply the principles of the Law of Large Numbers, both weak and strong forms, and Kolmogorov's three series theorem, in practical scenarios to analyze the behavior of random variables and understand the concept of independence of events and random variables.
CO4	Utilize central limit theorems, including Lindberg-Levy, Liapounov, and Lindberg-Feller, to analyze the behavior of sums of random variables and understand their implications in statistical inference, providing a solid foundation for advanced statistical analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Unit 1

Signed Measures and Decompositions: Signed measure space, singular and absolutely continuous measures, Radon-Nikodym theorem (without proof) and its applications. Decomposition of measures, Hahn Decomposition theorem, Hahn-Jordan decomposition, and Lebesgue decomposition theorem. Product space and product measure. Fubini's theorem (without proof). **(15 Hours)**

Unit 2

Characteristic Functions and Properties: Definition of a characteristic function, elementary properties, characteristic functions and moments, Taylor's series expansion of characteristic functions, Bochner's theorem (without proof), inversion theorem, uniqueness theorem, continuity theorem. **(15 Hours)**

Unit 3

Law of Large Numbers and Independence of the Class of Events: The Weak laws of large numbers, the strong laws of large numbers and Kolmogorov three series theorem (without proof), applications. Weak convergence of distributions. Independence of class of events and random variables. Borel 0-1 criteria and Borel-Cantelli Lemma, Kolmogorov 0-1 laws. **(15 Hours)**

Unit 4

Central Limit Theorems and Martingales: The central limit theorems – Lindberg Levy, Liapounov and Lindberg-Feller (without proof) central limit theorems, their mutual implications and applications. Conditional expectation, martingales, simple properties and examples. **(15 Hours)**

Unit 5

Illustration of WLLN and CLT using packages R/SPSS/SAS. **(15 Hours)**

Books for study:

1. Bhat, B.R. (2004). ***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Laha, R.G. and Rohatgi, V.K. (2020). ***Probability Theory,*** Dover Publications Inc.
3. Robert G. Bartle (1995). ***The Elements of Integration and Lebesgue Measure***, John Wiley & Sons, New York.
4. Rohatgi, V.K. (1976). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern.

Reference books:

1. Basu, A.K. (1999). ***Measure Theory and Probability***, Prentice-Hall.
2. Billingsley, P. (1986). ***Probability and Measure, Second Edition***, John Wiley.
3. Parthasarathy, K.R. (2005). ***Introduction to Probability and Measure***, Hindustan Book Agency.
4. Royden, H.L. (1988). ***Real Analysis (3rd edition)*** McMillan Publishing Company, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

A23 -DISCIPLINE SPECIFIC CORE COURSE

KU8DSCSTA402-SURVIVAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU8DSCSTA402	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of survival analysis, life distributions, and statistical methods for analyzing time-to-event data. Students will learn about survival functions, hazard rate functions, life distributions, nonparametric tests, censoring mechanisms, and advanced techniques such as Kaplan-Meier estimation and Cox proportional hazards regression.

COURSE OBJECTIVES:

- Understand the fundamentals of survival analysis, including discrete and continuous time models.
- Apply nonparametric tests such as the Kolmogorov-Smirnov test, sign test, signed-rank test, Mann-Whitney U test, Wilcoxon U test, and chi-square test for goodness of fit.
- Understand the concepts of censoring mechanisms including Type-I, Type-II, and random censoring.
- Apply Kaplan-Meier estimation technique to estimate survival probabilities.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Develop a solid understanding of survival analysis, including discrete and continuous time models, survival functions, hazard rate functions.
CO2	Gain proficiency in various life distributions such as exponential, Weibull, lognormal, and gamma distributions, including their characterizations.
CO3	Comprehend the concepts of censoring mechanisms, including Type-I, Type-II, and random censoring, as well as progressive censoring and truncation.
CO4	Develop practical skills in applying survival analysis techniques to real-world problems in biostatistics and epidemiology.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Basics of survival analysis- discrete and continuous time models, survival function, hazard rate function, probability density function, mean residual life time. Aging classes-IFR, IFRA and their duals, Bathtub failure rate. (**15 Hours**)

UNIT 2

Life distributions-exponential, Weibull, lognormal and gamma distributions, characterizations. Nonparametric tests- Kolmogorov-Smirnov test, sign test and signed-rank test, Mann-Whitney, Wilcoxon U test, chi- square test for goodness of fit, test for independence of attributes. (**15 Hours**)

UNIT 3

Concepts of censoring Mechanism -Type-I, Type-II and random censoring, Progressive censoring, Truncation, Methods for truncated and interval censored data. Likelihood construction and estimation of Censored and Truncated Data. Estimating survival rates using large scale data like DHS, NFHS, DLHS, etc. Comparing survival curves.
(**25 Hours**)

UNIT 4

Kaplan-Meier estimation technique: life tables, Mantel-Haenszel test. Interval estimation of survival probabilities. Introduction to survival regression. Cox proportional hazard model.
(**20 Hours**)

UNIT 5

Different characteristics of lifetime distribution: exponential, Weibull, log-normal and gamma distributions. **(15 Hours)**

TEXT BOOKS

1. Lawless, J.F. (2003): ***Statistical Methods for Lifetime*** *(Second Edition),* John Wiley & Sons Inc., New Jersey.
2. Kalbfleisch, J. D. and Prentice, R.L. (1980): ***The Statistical Analysis of Failure Time Data,*** John Wiley & Sons Inc. New Jersey.
3. Moore, D.F. (2016): ***Applied Survival Analysis Using R***, Springer.

SUGGESTED READINGS

1. Klein J.P. and Moeschberger M.L. (2003) ***Survival Analysis - Techniques for Censored and Truncated Data***, Second Edition, Springer-Verlag , New York.
2. Miller,R.G.(1981): ***Survival Analysis***, John Wiley & Sons Inc.
3. Bain,L.G.(1978*):* ***Statistical Analysis of Reliability and Life testing Models***, Marcel Decker.
4. Cox, D.R and Oakes, D.(1984): ***Analysis of Survival Data***. Chapman and Hall.
5. Fraser, D.A.S.(1957): ***Non-parametric Methods in Statistics***, Wiley, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA404: MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA404	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of advanced topics in multivariate statistical analysis, focusing on estimation, hypothesis testing, classification, principal component analysis, factor analysis, and clustering techniques. Throughout the course, students gain hands-on experience with multivariate data analysis techniques through practical exercises, case studies, and real-world applications. Emphasis is placed on developing analytical skills and understanding the theoretical foundations behind each method. By the end of the course, students will be equipped with the theoretical knowledge and practical skills necessary to analyze and interpret complex multivariate data, make informed statistical decisions, and apply advanced techniques in various domains such as finance, biology, and social sciences.

COURSE OBJECTIVES:

- Mastery of Estimation Techniques: Develop a comprehensive understanding of estimation methods for multivariate normal distributions, including moment estimators, maximum likelihood estimation, and confidence intervals for mean vectors and covariance matrices.
- Proficiency in Hypothesis Testing: Gain proficiency in hypothesis testing techniques for multivariate data, including likelihood ratio tests, Hotelling's T2 test, Mahalanobis's D2

statistic, MANOVA, and tests for equality of dispersion matrices and independence of subvectors.

- Understanding of Classification Methods: Understand the principles of classification in multivariate statistics, including discriminant analysis and Fisher's linear discriminant function, and apply these techniques to classify multivariate normal populations.
- Application of Principal Component Analysis (PCA): Learn the theory and application of PCA for summarizing sample variation using principal components, and understand its utility in dimensionality reduction and data visualization.
- Familiarity with Factor Analysis and Clustering Techniques: Acquire knowledge of factor analysis for identifying latent variables and clustering techniques for grouping similar observations, including hierarchical clustering, multidimensional scaling, and correspondence analysis.

COURSE OUTCOME:

After successful completion of this course, students will be able to understand the following

SL #	Course Outcomes
CO1	Develop advanced analytical skills in multivariate statistical analysis, enabling them to effectively analyze complex datasets, interpret results, and draw meaningful conclusions.
CO2	Demonstrate proficiency in statistical inference techniques for multivariate data, including estimation, hypothesis testing, and classification, allowing them to make informed decisions based on statistical evidence.
CO3	Gain competence in applying various multivariate data analysis techniques such as principal component analysis, factor analysis, and clustering methods to explore the underlying structure of data, identify patterns, and extract meaningful insights.
CO4	Applying statistical methods to real-world datasets and case studies, students will develop practical problem-solving skills and the ability to effectively communicate statistical findings and recommendations to diverse audiences.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

Unit 1

Estimation: Non-singular multivariate normal distribution, sample and likelihood function, moment estimators of mean and covariance matrix, maximum likelihood estimation of mean vector (when covariance matrix is known and unknown), confidence region, estimation of variance covariance matrix, estimation of common covariance matrix of several multivariate normal populations. **(15 Hours)**

Unit 2

Testing of Hypothesis: Likelihood ratio test, Hotelling's T^2 (one and two samples), Mahalanobi's D^2 statistic, relationship between T^2 and D^2 statistics, Fisher-Behren problem, MANOVA (one way and two-way), profile analysis, tests for different types of profiles, equality of dispersion matrices, testing the independence of subvectors, sphericity test. **(15 Hours)**

Unit 3

Classification Problem and Principal Component Analysis: The problem of classification - classification of one of two multivariate normal populations when the parameters are known and unknown and extension to several multivariate normal populations, discriminant analysis, Fisher's linear discriminant function. Population principal components - summarizing sample variation by principal components. **(15 Hours)**

Unit 4

Factor Analysis and Clustering: The orthogonal factor model, factor rotation, factor score, cluster analysis, proximity data, hierarchical clustering, non-hierarchical clustering methods, multidimensional scaling, correspondence analysis. **(15 Hours)**

Unit 5

Data entering in multivariate case and analysis using various R packages. **(15 Hours)**

Text Books:

1. Anderson, T.W. (2003): ***Multivariate Analysis***. John-Wiley, New York.
2. Johnson, R. A., & Wichern, D. W. (2019). ***Applied Multivariate Statistical Analysis.5TH Edition***, Springer.
3. Rao, C.R. (2002): ***Linear Statistical Inference and Its Applications***, Second Edition, John Wiley and Sons, New York.

Reference Books:

1. Kshirasagar, A.M. (1972): ***Multivariate Analysis.*** Marcel Dekker, New-York.
2. Rencher, A.C. (1998): ***Multivariate Statistical Analysis***. Jon Wiley, New York.
3. Morrison, D.F. (1976): ***Multivariate Statistical Methods***, McGraw Hill, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6 -DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA405: -STATISTICAL ANALYSIS OF CLINICAL TRIALS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA405	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of the fundamental principles and methodologies involved in designing, conducting, and analyzing clinical trials. It delves into the ethical considerations, protocol development, data management, and statistical techniques essential for the successful implementation of clinical research studies.

COURSE OBJECTIVES:

- Understand the importance and ethical considerations of clinical trials in medical research.
- Describe the different phases of clinical trials and their purposes.
- Calculate sample sizes for one-sample and two-sample cases in comparative trials and activity studies.
- Define and understand the goals of meta-analysis in clinical trials

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Comprehensive understanding of clinical trials, including their introduction, the necessity and ethical considerations, identification of bias and random errors, protocol development, conduct, and an overview of phases I-IV trials.
CO2	Acquire the ability to determine sample sizes in one and two-sample cases for comparative trials, activity studies, testing, and other purposes.
CO3	Gain proficiency in meta-analysis in clinical trials, understanding its concept, goals, and approaches including fixed and random effect approaches.
CO4	Develop practical skills in applying principles learned in clinical trial design, sample size determination, surrogate endpoint selection, and meta-analysis to real-world scenarios.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Clinical Trials: the need and ethics of clinical trials, bias and random error in clinical studies, Protocols, conduct of clinical trials, overview of Phase I-IV trials, Data management-data definitions, standard operating procedure, informed consent form, case report forms, database design, data collection systems for good clinical practice. (**15 Hours**)

UNIT 2

Design of Clinical Trials: Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization. Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs, Zelen's designs, design of bioequivalence trials. Outcome measures. (**15 Hours**)

UNIT 3

Sample Size Determination: comparative trials, activity studies, testing and other purposes, unequal sample sizes and case of ANOVA. Surrogate endpoints-selection and design of trials with surrogate, analysis of surrogate end point data. Reporting and analysis-Interpretation of result, multi-center trials. (**15 Hours**)

UNIT 4

Meta Analysis in Clinical Trials: concept and goals, fixed and random effect approaches. Bioassay: Direct and indirect assays, Quantal and quantitative assays, Parallel line and slope ratio assays, Design of bioassays. (**10 Hours**)

UNIT 5 (Teacher Specific Module-Optional)

Review of basic designs in clinical trials. **(5 Hours)**

TEXT BOOKS

1. Chen, D.G. and Peace, K.E. (2011). ***Clinical Trial Data Analysis Using R***. Chapman & Hall
2. Friedman, L. M., Furburg, C. D. Demets, L. (1998): ***Fundamentals of Clinical Trials***, Springer Verlag.
3. Kulinskaya E, Morgeathaler S, Staudte R G(2008). ***Meta analysis***, Wiley.

SUGGESTED READINGS

1. Das, M. N. and Giri(2008). ***Design of Experiments***, New Age, India
2. Turnbull (1999): ***Group Sequential Methods with Applications to Clinical Trials***, CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

A29– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA406:RELIABILITY MODELING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA406	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of reliability engineering, covering fundamental concepts, life distributions, shock models, and maintenance and replacement policies. Students will gain theoretical knowledge and practical skills necessary for analyzing, modeling, and optimizing the reliability of systems and components. Through theoretical lectures, practical exercises, and case studies, students will develop the skills necessary to analyze, design, and optimize reliable systems in various engineering and industrial applications.

COURSE OBJECTIVES:

- Understanding Fundamental Reliability Concepts: Develop a solid understanding of fundamental reliability engineering concepts including reliability measures, components and systems, coherent systems, and bounds on reliability.
- Mastery of Life Distributions: Gain proficiency in analyzing life distributions, including understanding reliability functions, hazard rates, and common life distributions such as exponential, Weibull, and Gamma distributions.
- Proficiency in Shock Models: Acquire proficiency in analyzing shock models, including univariate and bivariate shock models, and understanding common bivariate exponential distributions and their properties.
- Application of Maintenance and Replacement Policies: Develop skills in modeling maintenance and replacement policies for repairable systems, including understanding non-homogeneous Poisson processes, reliability growth models, and probability plotting techniques.
- Practical Application of Reliability Engineering Techniques: Apply reliability engineering techniques to real-world scenarios, including analyzing failure times in censored life tests, estimating stress-strength reliability, and conducting accelerated life testing.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate a proficient understanding of fundamental reliability engineering concepts, including reliability measures, coherent systems, and bounds on reliability, enabling them to analyze and evaluate the reliability of complex systems.
CO2	Possess advanced analytical skills in analyzing life distributions, including the ability to interpret reliability functions, hazard rates, and perform parameter estimation and hypothesis testing in various life distribution models.
CO3	Able to apply shock models to analyze reliability in univariate and bivariate contexts, understand common bivariate exponential distributions, and estimate reliability based on failure times in different testing scenarios.
CO4	Demonstrate proficiency in modeling maintenance and replacement policies for repairable systems using non-homogeneous Poisson processes, reliability growth models, and probability plotting techniques, facilitating optimal decision-making in system maintenance and replacement strategies.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

Unit 1

Basic Reliability Concepts: Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition;

bounds on reliability; structural and reliability importance of components. **(15 Hours)**

Unit-2

Life Distributions and Properties: Life distributions; reliability function; hazard rate; common life distributions - exponential, Weibull, Gamma, etc. Estimation of parameters and tests in these models. Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE classes and their duals; closures or these classes under formation of coherent systems, convolutions, and mixtures. **(15 Hours)**

Unit-3

Shock Models: Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. **(15 Hours)**

Unit -4

Maintenance and Replacement Policies: Repairable systems, replacement policies, modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing. **(15 Hours)**

Unit -5(Teacher Specific Module-Optional)

Computation of above concepts in R **(15 Hours)**

Book for Study

1. Barlow R.E. and Proschan F. (1985). ***Statistical Theory of Reliability and Life Testing***; Holt, Rinehart and Winston.

Reference Books

1. Bain L.J. and Engelhardt (1991). ***Statistical Analysis of Reliability and Life Testing Models***; Marcel Dekker.
2. Aven, T. and Jensen, U. (1999). ***Stochastic Models in Reliability***, Springer Verlag, New York, Inc.
3. Nelson, W. (1982). ***Applied Life Data Analysis***; John Wiley.
4. Zacks, S. (1992). ***Introduction to Reliability Analysis: Probability Models and Statistics Methods***. New York: Springer-Verlag.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct class room, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA407: ADVANCED BAYESIAN COMPUTING WITH R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU7DSESTA407	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to Bayesian inference, covering foundational concepts, single and multi-parameter models, Bayesian computation techniques, and model comparison and regression models. Students will gain theoretical knowledge and practical skills necessary for performing Bayesian analysis and inference using statistical software packages. Through theoretical lectures, practical exercises, and hands-on experience with statistical software packages, students will develop the skills necessary to perform Bayesian analysis, model complex data, and make informed decisions based on Bayesian inference.

COURSE OBJECTIVES:

- Understanding Bayesian Inference Principles: Develop a thorough understanding of Bayesian inference principles, including statistical decision problems, decision rules, loss functions, and Bayes' theorem, enabling students to apply Bayesian methods to real-world problems.
- Proficiency in Single and Multi-parameter Models: Gain proficiency in modeling single and multi-parameter distributions commonly encountered in Bayesian inference, such as the normal distribution, Poisson model, multinomial model, and multivariate normal distribution, allowing students to analyze and interpret complex data sets.
- Mastery of Bayesian Computation Techniques: Acquire mastery in Bayesian computation techniques, including Monte Carlo simulation, importance sampling, and Markov Chain Monte Carlo (MCMC) methods such as the Metropolis-Hastings algorithm and Gibbs sampling, enabling students to efficiently compute posterior distributions and perform Bayesian analysis.
- Ability to Compare Models and Perform Regression Analysis: Develop the ability to compare models using techniques such as Bayes factor and posterior predictive model checking. Gain proficiency in regression analysis, including hierarchical models, shrinkage estimators, and normal linear regression models, allowing students to make predictions and draw insights from data.

- Practical Application of Bayesian Methods: Apply Bayesian methods to real-world problems using statistical software packages such as R and WinBUGS, allowing students to perform Bayesian analysis, model complex data, and make informed decisions based on Bayesian inference techniques.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying Bayesian inference principles to solve a variety of statistical decision problems, effectively utilizing Bayes' theorem and decision rules to make informed decisions based on available data.
CO2	Develop advanced modeling skills in single and multi-parameter distributions commonly encountered in Bayesian inference, allowing them to accurately model and analyze complex datasets, including those with unknown parameters.
CO3	Master Bayesian computation techniques, including Monte Carlo simulation, importance sampling, and MCMC methods such as the Metropolis-Hastings algorithm and Gibbs sampling, enabling them to efficiently compute posterior distributions and perform Bayesian analysis on large datasets.
CO4	Gain proficiency in model comparison techniques such as Bayes factor and posterior predictive model checking, allowing them to assess the relative strengths of different models. Additionally, students will develop proficiency in regression analysis, including hierarchical models and normal linear regression models, enabling them to make accurate predictions and draw meaningful insights from data.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓		✓	✓	✓

COURSE CONTENTS

Unit 1

Bayesian Inference: Statistical decision problem, randomized decision rule, decision principle, standard loss functions, Prior information, subjective determination of prior density, non-informative priors, maximum entropy priors, conjugate priors, discrete prior. Parametric family and likelihood, exponential family, Bayes' theorem for inference, prior and posterior densities. **(15 Hours)**

Unit-2

Single and multi-parameter models: single parameter models, normal distribution with known variance and unknown mean, normal with known mean and unknown variance, Poisson model, normal distribution with both parameters unknown, multinomial model, Dirichlet prior, Bioassay experiment, comparing two proportions, predictive distribution, beta-binomial distribution, multivariate normal distribution, introduction to Learn Bayes package, Examples using Learn Bayes package. **(15 Hours)**

Unit-3

Bayesian Computation: Computing integrals using Monte-Carlo simulation, approximation based on posterior mode, importance sampling, Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, random walk, Gibbs sampling. **(15 Hours)**

Unit-4

Model Comparison and Regression models: Hierarchical models, shrinkage estimators, posterior predictive model checking, comparison of hypotheses, Bayes factor, one-sided test for normal mean, two-sided test for normal mean, normal linear regression model, prediction of future observations, examples and R codes, introduction to Win-BUGS package. **(15 Hours)**

Unit -5 (Teacher Specific Module-Optional)

Practical session in lab. **(30 Hours)**

Text Books

1. Jim Albert (2007). ***Bayesian Computation with R*,** New York: Springer Verlag.
2. Berger, O.J. (1985). ***Statistical Decision Theory and Bayesian Analysis, Second Edition***, Springer Verlag.
3. Bensal, A.K. (2008). ***Bayesian Parametric Inference*,** New Age, Delhi.

Reference Books:

1. Ferguson, T.S. (1967). ***Mathematical Statistics: A Decision-Theoretic Approach***, Academic Press, New York.
2. Bolstad, W. (2004). ***Introduction to Bayesian Statistics***, Hoboken, NJ: John Wiley.
3. Gelman, A., Carlin, J., Stern, H. and Rubin, D. (2003). ***Bayesian Data Analysis***, New York: Chapman and Hall.

4. Gilks, W.R., Richardson, S. and Spiegelhalter, D.J. (1996). ***Markov Chain Monte Carlo in Practice***. Chapman & Hall/CRC, New York.
5. Robert, C. and Casella, G. (2004). ***Monte Carlo Statistical Methods***, New York: Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct class room, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

A9-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA408: GENERALIZED LINEAR MODELS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	500	KU8DSESTA408	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into the theory and applications of generalized linear models (GLMs), focusing on various advanced topics such as logistic regression, Poisson regression, log-linear models, zero-inflated models, and survival analysis. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of GLMs and their applications in analyzing complex data sets.

COURSE OBJECTIVES:

- Define and explain the key concepts of GLMs, including the exponential family of distributions, link functions, and model specification.
- Apply the method of maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate GLM parameters.
- Explore specialized GLM models such as Poisson regression and log-linear models for count data analysis.
- Apply GLMs to analyze hierarchical and longitudinal data using techniques such as generalized estimating equations (GEE) and mixed effects models.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying advanced GLM techniques such as logistic regression, Poisson regression, and log-linear models to analyze complex datasets.
CO2	Utilize maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate parameters in GLMs.
CO3	Apply GLMs to analyze count data using Poisson regression and handle excessive zeros using zero-inflated models.
CO4	Interpret GLM parameters and assess the significance of predictor variables in the context of the research question.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Introduction to Generalized Linear Models: Overview of generalized linear models (GLM s), exponential family of distributions, link functions and model specification, logistic regression, comparison with linear regression and logistic regression, interpretation of GLM parameters, nominal and ordinal regression. (**15 Hours**)

UNIT 2

Model Estimation and Inference: Method of maximum likelihood estimation, iteratively reweighted least squares (IRLS) algorithm, model diagnostics: residual analysis, goodness-of-fit tests, confidence intervals and hypothesis testing for model parameters, overdispersion and model assessment. **(25 Hours)**

UNIT 3

Poisson Regression and Log-linear Models: Count data, Poisson regression, Estimation and model diagnostics, Contingency tables, log-linear models, Inference for log-linear models, Numerical examples, zero-inflated Poisson models. **(20 Hours)**

UNIT 4

Advanced Topics in GLMs: Generalized estimating equations (GEE), zero-inflated and negative binomial models, hierarchical GLM s and mixed effects models, time-to-event data analysis using GLM s (survival analysis), model selection techniques: AIC, BIC. (**20 Hours)**

UNIT 5

Applications of GLM s in biomedical research, epidemiology, and social sciences, case studies and real-world examples, practical implementation of GLM s using statistical software (R or SAS or SPSS).

(10 Hours)

TEXT BOOKS

1. Dobson, A. J., & Barnett, A. G. (2018). ***An Introduction to Generalized Linear Models*** *(4th ed.)*. CRC Press.
2. McCullagh, P., & Nelder, J. A. (1989). ***Generalized Linear Models*** *(2nd ed.)*. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Faraway, J. J. (2006). ***Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models.*** Chapman and Hall/CRC.
2. Agresti, A. (2015). ***Foundations of Linear and Generalized Linear Models.*** John Wiley & Sons.
3. Hardin, J. W., & Hilbe, J. M. (2013). ***Generalized Linear Models and Extensions (3rd ed.).*** Stata Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA409-ANALYSIS OF LONGITUDINAL DATA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA409	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into advanced statistical methodologies for analyzing longitudinal data, focusing on discrete outcomes, generalized linear models, missing data mechanisms, time-dependent covariates, and special topics in longitudinal data analysis. Through theoretical concepts, practical applications, and case studies, students will develop proficiency in modeling longitudinal data and addressing complex research questions in various fields.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of advanced statistical techniques for analyzing longitudinal data, including generalized linear models, random effects models, transition models, and likelihood-based models for categorical data.
- Learn to classify missing data mechanisms, address intermittent missing values and dropouts, and implement weighted estimating equations and modeling techniques for the dropout process.
- Recognize the challenges associated with time-dependent covariates, implement lagged covariates, and apply marginal structural models to account for time-varying confounding factors.
- Gain insight into specialized topics such as joint models for longitudinal and survival data, multivariate longitudinal data analysis, and the design of randomized and observational longitudinal studies.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Conduct analysis of longitudinal data.
CO2	Apply statistical techniques to model longitudinal data and make predictions.
CO3	Understand analysis of longitudinal data with missing data.
CO4	Understand analysis of longitudinal data with time-dependent covariates.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Discrete Data and their Measures: Inference for contingency tables, Logistic models, statistical power and sample size computations Logit models with categorical predictors, logit models with multi responses-nominal and ordinal responses.
(20 Hours)

UNIT 2

Generalized Linear Model for Longitudinal Data: Generalized Linear Model for Longitudinal Data, Marginal models, for binary, ordinal, and count data: Random effects models for binary and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses. (20 Hours)

UNIT 3

Longitudinal Data with Missing Data: Classification missing data mechanism; Intermittent missing values and dropouts; Weighted estimating equations; Modeling the dropout process (Selection and pattern mixture models). (15 hours)

UNIT 4

Time-dependent Covariates and Special Topics: Dangers of time-dependent covariates, Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies. (20Hours)

UNIT 5

Exploratory Data Analysis, Modeling Approaches: Students will apply various modeling approaches discussed in earlier units, such as Generalized Linear Models (GLMs), Generalized Estimating Equations (GEE), and Marginal Structural Models (MSMs), to analyze longitudinal data using statistical software. (15 Hours)

TEXT BOOKS

1. Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). ***Analysis of Longitudinal Data***, 2nd Edn. Oxford University Press, New York.
2. Fitzmaurice, G.M., Laird, N.M and Ware, J.H. (2004). ***Applied Longitudinal Analysis***, John Wiley & Sons, New York.

SUGGESTED READINGS

1. Crowder, M.J. and Hand, D.J. (1990). ***Analysis of Repeated Measures.*** Chapman and Hall/CRC Press, London.
2. Davidian, M. and Giltinan, D.M. (1995). ***Nonlinear Models for Repeated Measurement Data***. Chapman and Hall/CRC Press, London.
3. Hand, D. and Crowder, M. (1996). ***Practical Longitudinal Data Analysis.*** Chapman and Hall/CRC Press, New York.
4. McCullagh, P. and Nelder. J. A. (1989). ***Generalized Linear Models. 2nd Edition***, Chapman and Hall/CRC Press, London.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA410-APPLIED REGRESSION ANALYSIS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA410	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of regression analysis, covering simple linear regression models, multiple regression models, nonparametric regression, simultaneous equation models, polynomial regression, linearization transforms, diagnostic checks, and generalized linear models. Students will learn theoretical concepts, practical applications, and advanced techniques for analyzing and interpreting regression models.

COURSE OBJECTIVES:

- Understand various regression models including logistic regression models and simultaneous equation models.
- Understand consequences of multicollinearity, heteroscedasticity, autocorrelation, their detection, and remedial measures.
- Apply statistical techniques to model relationships between variables and make predictions.

- Acquire knowledge of various advanced econometric models, estimation methods, and related econometric theories.
- Conduct econometric analysis of data.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understand the concepts of simple linear regression models and least square estimation.
CO2	Recognize the nature and consequences of multicollinearity, heteroscedasticity, and autocorrelation in regression models.
CO3	Understand the principles of nonparametric regression and spline smoothing techniques.
CO4	Apply linearization transforms to linearize nonlinear relationships in regression models.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

The Simple Linear Regression Models, least square estimation, statistical assumptions and properties of estimators, standard error of estimates, tests of significance and confidence intervals for the parameters, error and residual plots.
(**20 Hours**)

UNIT 2

Multiple Regression Models : Multiple regression models, OLS and ML estimators, testing and prediction, Multicollinearity, heteroscedasticity, autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them..
(**20 Hours**)

UNIT 3

Nonparametric Regression - Nonparametric regressions and concept of spline smoothing. Simultaneous equation models - examples, inconsistency of OLS estimators, identification problem, rules for identification, method of indirect least squares, method of two-stage least squares. (**20 Hours**)

UNIT 4

Polynomial Regression in One and Several Variables. Linearization transforms, Diagnostic checks and correction. Generalized linear models. Logistic regression. Poisson regression, application in biostatistics. (**15 Hours**)

UNIT 5

Review of Gauss-Markov model, estimability of linear parametric function, different problems related to estimability. Hands-on exercises using statistical software.
(**15 Hours**)

TEXT BOOKS

1. Draper, N.R. and Smith, H. (1998): ***Applied Regression Analysis***, 3rd Ed. John Wiley.
2. Gujarati, D.N. (2007): ***Basic Econometrics*** (Fourth Edition), McGraw-Hill, New York.
3. Hosmer, D.W. and Lemeshow, S. (1989): ***Applied Logistic Regression***, John Wiley.
4. Montgomery, D.C, Peek, E.A. and Vining, G.G. (2006): ***Introduction to Linear Regression Analysis***, John Wiley.

SUGGESTED READINGS

1. Seber, G.A.F. and Lee, A.J. (2003): ***Linear Regression Analysis***, Wiley

2. Johnston, J. (1984): ***Econometric Methods***, 3rd ed., McGraw Hill, New York.
3. Goon, Gupta, Das Gupta (2001): ***An Outline Series in Statistics Vol I***, World Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA411- STATISTICAL EPIDEMIOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA411	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an introduction to the fundamental principles and methodologies of epidemiology, focusing on understanding the distribution and determinants of health-related states or events in populations and the application of this knowledge to public health practice. Through a combination of theoretical concepts and practical examples, students will gain insight into various study designs, measures of disease frequency and association, and the role of epidemiology in disease prevention and control.

COURSE OBJECTIVES:

- Explain the concepts of health and disease and the methods for measuring them.
- Describe the characteristics and applications of cohort and case-control study designs.
- Perform estimation and hypothesis testing using confidence intervals and analysis of variance (ANOVA).
- Understand the concept of causation in epidemiology and methods for establishing causality.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understand the different types of study designs, including observational epidemiology, cohort study designs, case-control study designs, randomized field trials, and control trials.
CO2	Comprehend the concept of cause and establishing the cause of disease.
CO3	Describe the scope and levels of disease prevention and their relevance to public health practice.
CO4	Develop practical skills in applying epidemiological principles to public health problems.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS

UNIT 1

Basic concepts of epidemiology: definition and scope of epidemiology, achievements in epidemiology, measuring health and disease, definition of health and disease, measures of disease frequency, comparing disease occurrence.
(**15 Hours**)

UNIT 2

Types of study: observations and experiments, observational epidemiology, cohort study designs, case control study designs, randomized, field trails, control trials, potentials errors in epidemiological studies, ethical issues. (**15 Hours**)

UNIT 3

Distribution and summary measures: distribution, measures of central tendency, measures of variability, normal and log normal distributions, estimation, testing, CI, ANOVA, relationship between two variables: chi-square test, correlation, regression, logistic regression. (**25 Hours**)

UNIT 4

Concept of cause and Study Designs: Establishing the cause of disease, scope of prevention, levels of prevention, Introduction to clinical epidemiology. Advanced Study Designs: Delve into more complex study designs beyond cohort and case-control studies, such as nested case-control studies, case-crossover studies, ecological studies, and cross-sectional studies. (**20 Hours**)

UNIT 5

Social Epidemiology: Investigate the social determinants of health and disease disparities within populations. Stay abreast of current and emerging topics in epidemiological research. (**15 Hours**)

TEXT BOOKS

1. Beaglehole,R.,Bonita,R.andKjellstorm,T.(1993).***Basic Epidemiology***.World Health Organization, Geneva.
2. Newman,S.C.(2001).***Biostatistical Methods in Epidemiology***. John Wiley & Sons, New York.
3. Virasakdi, C. (2010). ***Analysis of Epidemiological Data Using R and Epicalc.*** **Epidemiological Unit**, Songla University,Thailand

SUGGESTED READINGS

1. Rothan,K.J.,Greenland,S.and Lash,T.L.(2008). ***Modern Epidemiology***, *3rd Edition.* Wokers Kluver
2. Clayton,D.and Hills,M.(1993). ***Statistical methods in epidemiology***. Oxford University Press4. Karlin, S. and Taylor, H.M. (1975). **A First Course in Stochastic Processes**. Second Edition, Academic Press. New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA412-STATISTICAL ECOLOGY AND GENETICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA412	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of population dynamics, ecological diversity, statistical problems in human genetics, and sequence analysis techniques. Through theoretical concepts and practical applications, students will gain insight into the dynamics of populations, ecological diversity measures, genetic inheritance, and sequence analysis algorithms.

COURSE OBJECTIVES:

- Understand the dynamics of populations, including single-species and two-species models, and analyze population growth using mathematical models such as exponential, logistic, and Gompertz models.
- Apply ecological diversity measures such as Simpson's index and Shannon-Weaver index to quantify species diversity in ecological communities and understand the concept of average rarity in biodiversity conservation.

- Explore statistical problems in human genetics, including blood group analysis, quantitative genetics, inheritance of quantitative traits, detection, and estimation of linkage, and understand the principles of Hardy-Weinberg Equilibrium and random mating.
- Gain proficiency in sequence analysis techniques, including sequence similarity, homology, and alignment algorithms such as pair and multiple sequence alignments, construction of phylogenetic trees using UPGMA, neighbor joining, maximum parsimony, and maximum likelihood algorithms.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understanding Population Dynamics and Models.
CO2	Proficiency in Population Density Estimation and Ecological Diversity.
CO3	Application of Statistical Methods in Human Genetics.
CO4	Proficiency in Sequence Analysis and Phylogenetics.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

UNIT 1

Population Dynamics: One species - exponential, logistic and Gompertz models. Two species - competition, coexistence, predator - prey oscillation, Lotka - Volterra equations, isoclines. Leslie matrix model for age structured populations. Survivorship curves - constant hazard rate, monotone hazard rate and bath-tub shaped hazard rates.

(**15 Hours**)

UNIT 2

Population density estimation -Capture- recapture models, nearest neighbor models, line transect sampling. Ecological Diversity - Simpson's index, Shannon – Weaver index, Diversity as average rarity. Optimal Harvesting of Natural Resources, Maximum sustainable yield, tragedy of the commons.

(**15 Hours**)

UNIT 3

Statistical problems in human genetics: blood group analysis. Natural selection. Quantitative genetics, study of inheritance of quantitative characters in random and nonrandom mating diploid populations. Detection and estimation of linkage. Gene frequency, random mating, Hardy-Weinberg Equilibrium, Matrix theory of random mating with applications. (**15 Hours**)

UNIT 4

Sequence similarity: homology and alignment. Algorithm for pair and multiple sequence alignments, construction of phylogenetic trees, UPGMA. Neighbor joining, maximum parsimony and maximum likelihood algorithms. (**10 Hours**)

UNIT 5

Genetic Variation and Evolution: Explore the sources and maintenance of genetic variation within populations, including mutation, migration, genetic drift, and natural selection. (**5 Hours**)

TEXT BOOKS

1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995). ***Continuous Univariate Distributions, Vol. I & Vol. II***, John Wiley and Sons, New York.
2. MacLachlan, P. and Peel, D. (2000). ***Finite Mixture Models***. John Wiley & Sons, New York
3. Silverman, B. (1986). ***Density Estimation for Statistics and Data Analysis***. Chapman & Hall.

SUGGESTED READINGS

1. Johnson, N.L., Kotz, S. and Kemp, A.W. (1992). ***Univarite Discrete Distributions***, John Wiley and Sons, New York.
2. Stuart, A., Ord, A. (1994). ***Kendall's Advanced Theory of Statistics, Distribution Theory***, 6th Edition. Wiley-Blackwell.
3. Kagan, A.M., Linnik, Y.V. and Rao, C.R. (1975). ***Characterization Problems in Mathematical Statistics.*** John Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester VIII

DSE6-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU8DSESTA413 - APPLIED MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSESTA413	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of multivariate statistical analysis techniques, covering topics such as multivariate normal distribution, principal component analysis, canonical correlation analysis, factor analysis, cluster analysis, MANOVA, and multidimensional scaling. Students will learn theoretical concepts and practical applications of these techniques using statistical software.

COURSE OBJECTIVES:

- Understand the fundamentals of multivariate data analysis and the notion of multivariate distributions.
- Demonstrate proficiency in analyzing multivariate data using the multivariate normal distribution, including understanding marginal and conditional distributions.
- Master the concept of characteristic functions and their application in multivariate data analysis.
- Develop skills in estimating the mean vector and covariance matrix of multivariate datasets.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate a comprehensive understanding of various multivariate data analysis techniques.
CO2	Develop proficiency in dimensionality reduction techniques such as Principal Components Analysis (PCA) and Factor Analysis.
CO3	Acquire advanced multivariate analysis skills, including conducting comparisons of several multivariate population means using one-way MANOVA, simultaneous confidence interval construction for treatment effects.
CO4	Master the analysis of multivariate relationships using techniques such as Canonical Correlation Analysis (CCA), cluster analysis, and distance methods.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Multivariate normal distribution: Multivariate data, preliminary analysis, notion of multivariate distributions, multivariate normal distribution, marginal and conditional distributions, characteristic function, estimation of mean vector and covariance matrix. (**15 Hours**)

UNIT 2

Principal component and canonical correlation: Principal components Analysis: - population principal components, summarizing sample variation by principal components, graphing the principal components; Canonical correlation analysis: - canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations. (**25 Hours**)

UNIT 3

Factor and cluster analysis: Factor analysis: - orthogonal factor model; methods of estimation, factor rotation, factor scores; Cluster analysis: - similarity measures, hierarchical clustering methods, non-hierarchical clustering methods.
(**25 Hours**)

UNIT 4

MANOVA and Multidimensional scaling: Comparison of several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatment effects, two-way multivariate analysis of variance; Distance methods: - multidimensional scaling, correspondence analysis. (**15 Hours**)

UNIT 5

Multivariate Data Analysis in R: Introduction to R programming language for multivariate data analysis; Multivariate statistical techniques implementation in R: using packages like "mvtnorm" for multivariate normal distribution, "FactoMineR" for factor analysis and cluster analysis, "MASS" for MANOVA. Hands-on exercises and case studies: applying learned techniques to real-world datasets, interpreting results, and drawing conclusions. (**10 Hours**)

TEXT BOOKS

1. Johnson, R.A. and Wichern, D.W. (2007). ***Applied Multivariate Statistical Analysis***, PHI Learning Private Ltd, New Delhi, Sixth edition.
2. Rencher, A.C. (1995) . ***Methods of Multivariate Analysis***, John Wiley.
3. Dillon, W.R. and Goldstein, M (1984) . ***Multivariate Analysis***, John Wiley.

SUGGESTED READINGS

1. Anderson, T.W. (1984). ***An Introduction to Multivariate Statistical Analysis***, John Wiley.
2. Seber G.A.F. (1983) . ***Multivariate Observations***, Wiley.
3. Tabachnick, B.G. and Fidell, L.S. (2018) . ***Using Multivariate Statistics,*** Sixth edition, Pearson India Education Services Pvt Ltd, India.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A24– DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA501: ADVANCED SAMPLING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA501	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive overview of sampling methods in statistics, covering basic concepts, probability sampling techniques, auxiliary variable techniques, varying probability sampling, and cluster, multi-stage, and multi-phase sampling. Students will gain theoretical knowledge and practical skills necessary for designing and implementing sampling plans and estimating population parameters accurately. Through theoretical lectures, practical exercises, and case studies, students will develop the skills necessary to design effective sampling plans, select appropriate sampling techniques, and estimate population parameters accurately while considering various sampling complexities and constraints.

COURSE OBJECTIVES:

- Understanding Sampling Concepts: Develop a thorough understanding of basic sampling concepts, including the distinction between census and sampling, types of sampling methods, and the principles underlying probability and non-probability sampling.
- Proficiency in Probability Sampling Techniques: Gain proficiency in probability sampling techniques such as simple random sampling, systematic sampling, and stratified random

sampling, including the estimation of population parameters like mean, total, and proportions.

- Mastery of Auxiliary Variable Techniques: Acquire mastery in auxiliary variable techniques, including the ratio method of estimation and regression methods of estimation, and understand concepts such as bias, relative bias, mean squared error, and comparison of estimators.
- Application of Varying Probability Sampling Methods: Develop the ability to apply varying probability sampling methods such as probability proportional to size (PPS) sampling, Des-Raj ordered estimators, Murthy's unordered estimator, and Horwitz-Thompson estimators.
- Proficiency in Cluster, Multi-Stage, and Multi-Phase Sampling: Gain proficiency in cluster sampling techniques, including equal and unequal clusters, and understand concepts such as relative efficiency and optimum cluster size. Develop skills in multi-stage and multi-phase sampling methods and recognize sources of non-sampling errors.

COURSE OUTCOME:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate mastery of various sampling techniques, including probability and non-probability sampling methods, enabling them to design and implement effective sampling plans for diverse populations and research contexts.
CO2	Develop proficiency in estimation methods for population parameters such as mean, total, and proportions using different sampling techniques, auxiliary variable techniques, and varying probability sampling methods, ensuring accurate estimation of population characteristics.
CO3	Develop advanced analytical skills in evaluating the performance of different sampling methods, comparing estimators, and assessing the reliability of survey results, enhancing their ability to make informed decisions based on sample data.
CO4	Apply sampling principles to real-world scenarios and datasets, students will develop practical skills in designing sampling plans, selecting appropriate sampling techniques, and addressing potential sources of bias and error, ensuring the validity and reliability of survey findings.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

Unit-1

An Overview of Basics of Sampling: Census and sampling - basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement, estimation of population mean and total, estimation of sample size, estimation of proportions. Systematic sampling, linear and circular systematic sampling, estimation of mean and its variance, estimation of mean in populations with linear and periodic trends. **(15 Hours)**

Unit-2

Stratified Random Sampling and Auxiliary Variable Techniques: Stratification and stratified random sampling. Optimum allocations, comparisons of variance under various allocations. Auxiliary variable techniques, Ratio method of estimation, estimation of ratio, mean, and total. Bias and relative bias of ratio estimator. Mean squared error of ratio estimator. Unbiased ratio type estimator. Regression methods of estimation. Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population.
(15 Hours)

Unit-3

Varying Probability Sampling: Varying probability sampling – pps sampling with and without replacements. Des-Raj ordered estimators, Murthy's unordered estimator, Horwitz-Thompson estimators, Zen-Midzuno scheme of sampling, PPS sampling.
(15 Hours)

Unit-4

Cluster, Multi-Stage, and Multi-Phase Sampling: Cluster sampling with equal and unequal clusters. Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling. Multi-stage and multi-phase sampling. Non-sampling errors.
(15 Hours)

Unit -5

Practicals using various R packages for sampling.
(15 Hours)

Books for Study

1. Singh, D. and Chowdhary, F.S. (1986). ***Theory and Analysis of Sample Survey Designs***, New Age International, New Delhi.
2. Cochran, W.G. (2007). ***Sampling Techniques***, John Wiley & Sons, New York.

Reference Books

1. Des Raj, D. and Chandhok, P. (1998). ***Sample Survey Theory***, Narosa Publishing House, New Delhi.
2. Gupta and Kapoor (2010). ***Fundamentals of Applied Statistics***. Sulthan Chand & Sons.
3. Murthy, M.N. (1967). ***Sampling Theory & Methods***. Statistical Publishing Society, Calcutta.
4. Parimal Mukopadhyay (2012). ***Theory & Methods of Survey Sampling***, PHI Learning, New Delhi.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct classroom lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A25-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA502- STOCHASTIC PROCESSES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA502	4	90

Learning Approach (Hours/ Week)	Marks Distribution	Duration of

Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	ESE (Hours)
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of stochastic processes, Markov chains, renewal processes, queueing theory, and Brownian motion. Students will delve into theoretical concepts and practical applications of these stochastic models in various fields such as operations research, telecommunications, finance, and engineering. Through lectures, problem-solving sessions, and hands-on exercises, students will gain proficiency in analyzing and modeling stochastic systems.

COURSE OBJECTIVES:

- Understand the concepts of Stochastic Processes.
- Understand the concepts of Markov chains, classification of its states and limiting probabilities.
- Understand continuous time Markov chains, Poisson processes and its generalizations.
- Understand the branching processes, various queueing models and Brownian motion processes.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Introduction to counting processes and their significance in modeling arrivals over time.
CO2	Exploring generalizations of Poisson processes such as non-homogeneous Poisson processes and compound Poisson processes.
CO3	Analysis of traffic intensity, expected queue size, expected system size, and waiting time in queueing systems.
CO4	Understanding Brownian motion and its applications in modeling random motion and diffusion phenomena.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Overview of basic concepts of stochastic processes and Markov Chains: Poisson Processes and Generalizations: Exponential distribution, counting process, inter-arrival time and waiting time distributions. Properties of Poisson processes - Conditional distribution of arrival times. Generalizations of Poisson processes, non-homogeneous Poisson process, compound Poisson process.
(15 Hours)

UNIT 2

Continuous-time Markov Chains and Renewal Processes: Continuous-time Markov Chains - Birth and death processes, transition probability function, limiting probabilities. Renewal processes, limit theorems and their applications. Semi-Markov process. **(15 Hours)**

UNIT 3

Queueing theory: Basic characteristics of queues- traffic intensity, expected queue size, expected system size, waiting time, Littles equation, steady-state characteristics, analysis of Markovian models (M/M/1, M/M/1/N, M/M/c), network of queues. The M/G/1 system and G/M/1 mode **(15 Hours)**

UNIT 4

Brownian motion and stationary process: hitting times, maximum variables, gambler's ruin problem, variations on brownian motion, brownian motion with drift, geometric brownian motion, applications. **(8 Hours)**

UNIT 5

Continuous-Time Stochastic Processes: Introduction to continuous-time stochastic processes beyond Markov chains, Introduction to Brownian motion and stochastic calculus and its applications. **(7 Hours)**

TEXT BOOKS

1. Ross, S.M. (2010). ***Introduction to Probability Models. Xth Edition***, Academic Press.
2. Medhi, J. (2009). ***Stochastic Processes. Third Edition.*** New Academic Science Limited. UK.

SUGGESTED READINGS

1. Basu, A.K. (2002). ***Elements of Stochastic Processes***, Narosa Publications.
2. Cinlar, E. (1975). ***Introduction to Stochastic Processes***. Prentice Hall. New Jersey.
3. Feller, W. (1965, 1968). ***An Introduction to Probability Theory and Its Applications,*** Volume I and II, Wiley Eastern.
4. Karlin, S. and Taylor, H.M. (1975). ***A First Course in Stochastic Processes. Second Edition***, Academic Press. New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A26-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA503- STATISTICAL SIMULATION TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA503	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive introduction to statistical simulation techniques, covering theoretical foundations, methods for generating random variables and stochastic processes, Monte Carlo simulation methods, and applications in various fields such as finance, engineering, and risk analysis. Through theoretical instruction, practical examples, and hands-on exercises, students will gain proficiency in using statistical simulation to model complex systems and make informed decisions.

COURSE OBJECTIVES:

- Theoretical foundations of statistical simulation techniques and their applications in various fields.
- Methods for generating random variables and simulating stochastic processes.
- Techniques for implementing Monte Carlo simulations to solve complex statistical problems.
- Interpretation of results from statistical simulations and their implications in decision-making and risk analysis.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understand the theoretical foundations of statistical simulation techniques and their importance in modern statistical analysis.
CO2	Apply methods for generating random variables from different probability distributions and simulating stochastic processes.
CO3	Implement Monte Carlo simulation methods to solve problems involving uncertainty and variability.
CO4	Interpret results obtained from statistical simulations and make informed decisions based on simulation outputs.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Statistical Simulation Techniques: Definition and scope of statistical simulation, Theoretical foundations of random number generation, Basics of probability distributions and random variables. (**15 Hours**)

UNIT 2

Generation of Random Variables and Stochastic Processes: Methods for generating random variables from different distributions, Simulation techniques for discrete and continuous stochastic processes, Simulation of Markov chains and random walks. (**25 Hours**)

UNIT 3

Monte Carlo Simulation Methods: Principles of Monte Carlo simulation, Simulation of complex systems and processes, Variance reduction techniques in Monte Carlo simulation, Applications in finance, engineering, and risk analysis. (**25 Hours**)

UNIT 4

Interpretation and Applications of Statistical Simulations: Analysis and interpretation of simulation results, Applications of statistical simulations in decision-making and risk analysis, Case studies and real-world examples. **(15 Hours)**

UNIT 5(Teacher Specific Module-Optional)

Variance Reduction in Monte Carlo Simulation, Introduction to stratified sampling, importance sampling, and control variates, Implementation of variance reduction techniques in R. (**10 Hours)**

TEXT BOOK

1. Robert, C. P., & Casella, G. (2004). ***Monte Carlo Statistical Methods.*** Springer.

SUGGESTED READINGS

1. Rubinstein, R. Y., & Kroese, D. P. (2016). ***Simulation and the Monte Carlo Method (3rd ed.)***. John Wiley & Sons.
2. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (2013). ***Bayesian Data Analysis (3rd ed.)***. CRC Press.
3. Fishman, G. S. (2013). ***Monte Carlo: Concepts, Algorithms, and Applications***. Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A27-DISCIPLINE SPECIFIC CORE COURSE

KU09DSESTA504 - ADVANCED MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSESTA504	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of multivariate statistical analysis techniques, covering topics such as multivariate normal distribution, principal component analysis, canonical correlation analysis, factor analysis, cluster analysis, MANOVA, and multidimensional scaling. Students will learn theoretical concepts and practical applications of these techniques using statistical software.

COURSE OBJECTIVES:

- Understand the fundamentals of multivariate data analysis and the notion of multivariate distributions.
- Demonstrate proficiency in analyzing multivariate data using the multivariate normal distribution, including understanding marginal and conditional distributions.

- Master the concept of characteristic functions and their application in multivariate data analysis.
- Develop skills in estimating the mean vector and covariance matrix of multivariate datasets.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate a comprehensive understanding of various multivariate data analysis techniques.
CO2	Develop proficiency in dimensionality reduction techniques such as Principal Components Analysis (PCA) and Factor Analysis.
CO3	Acquire advanced multivariate analysis skills, including conducting comparisons of several multivariate population means using one-way MANOVA, simultaneous confidence interval construction for treatment effects.
CO4	Master the analysis of multivariate relationships using techniques such as Canonical Correlation Analysis (CCA), cluster analysis, and distance methods.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

UNIT 1

.**Principal Component and Canonical Correlation:** Principal components Analysis: -population principal components, summarizing sample variation by principal components, graphing the principal components; Canonical correlation analysis: - canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations.

(**25 Hours**)

UNIT 2

Factor and Cluster Analysis: Factor analysis: - orthogonal factor model; methods of estimation, factor rotation, factor scores; Cluster analysis: - similarity measures, hierarchical clustering methods, non-hierarchical clustering methods.

(**20 Hours**)

UNIT 3

MANOVA and Multidimensional Scaling: Comparison of several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatment effects, two-way multivariate analysis of variance; Distance methods: - multidimensional scaling, correspondence analysis. (**25 Hours**)

UNIT 4

Multivariate Linear regression models: Least Squares Estimation, Inferences Concerning the Regression Parameters, Estimating the Regression Function, Forecasting a New Observation, Model Checking and Other Aspects of Regression, Likelihood Ratio Tests for Regression Parameters, multivariate multiple regression, Other Multivariate Test Statistics, Predictions from Multivariate Multiple Regressions.

(**15 Hours**)

UNIT 5 (Teacher specific module-Optional)

Multivariate Data Analysis in R: Introduction to R programming language for multivariate data analysis; Multivariate statistical techniques implementation in R: using packages like "mvtnorm" for multivariate normal distribution, "FactoMineR" for factor analysis and cluster analysis, "MASS" for MANOVA. Hands-on exercises and case studies: applying learned techniques to real-world datasets, interpreting results, and drawing conclusions. (**10 Hours**)

TEXT BOOKS

1. Johnson, R.A. and Wichern, D.W. (2007)**.** ***Applied Multivariate Statistical Analysis***, PHI Learning Private Ltd, New Delhi, Sixth edition.
2. Rencher, A.C. (1995) . ***Methods of Multivariate Analysis***, John Wiley.
3. Dillon, W.R. and Goldstein, M (1984) . ***Multivariate Analysis***, John Wiley.

SUGGESTED READINGS

1. Anderson, T.W. (1984). ***An Introduction to Multivariate Statistical Analysis***, John Wiley.
2. Seber G.A.F. (1983) . ***Multivariate Observations***, Wiley.
3. Tabachnick, B.G. and Fidell, L.S. (2018) . ***Using Multivariate Statistics,*** Sixth edition, Pearson India Education Services Pvt Ltd, India.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A28-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA505- ADVANCED DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA505	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of experimental design principles and statistical analysis techniques commonly used in research settings. Students will learn about linear models, analysis of variance (ANOVA), complete and incomplete block designs, factorial designs, and their applications in various experimental settings. Through theoretical concepts and practical examples, students will develop the skills necessary to design and analyze experiments effectively.

COURSE OBJECTIVES:

- Understand the fundamental principles of experimental design and analysis, including linear models, estimable functions, and best estimates.
- Apply appropriate statistical techniques to analyze experimental data, including ANOVA, non-parametric methods, and factorial designs.
- Demonstrate proficiency in planning and conducting experiments, including considerations for fixed, random, and mixed models.
- Interpret experimental results effectively and make informed conclusions based on statistical analysis, considering factors such as confounding and partial confounding in factorial designs.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Apply ANOVA for one-way and two-way classification, fixed effect models with equal and unequal number of observations per cell, Random and Mixed effect models.
CO2	Design and analyze incomplete block designs, understand the concepts of orthogonality, connectedness, and balance.
CO3	Identify the effects of different factors and their interactions and analyze factorial experiments.
CO4	Construct complete and partially confounded factorial designs and perform their analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Linear Models: Linear model, estimable functions and best estimate, normal equations, distribution of sum of squares, estimate and error sum of squares, test of linear hypothesis, basic principles and planning of experiments. The fixed, random, and mixed models. The single and two-factor ANOVA. Non-parametric method in the analysis of variance, Kruskal-Wallis test. **(25 Hours)**

UNIT 2

Complete Block Designs: Complete Block Designs - Completely Randomized Design, Randomized Block Design, Latin Square Design, Greaco Latin Square Design, Analysis with Missing Values, ANCOVA. (**15 Hours**)

UNIT 3

Incomplete Block Designs: Incomplete Block Designs - BIBD, recovering of Intra Block Information in BIBD, construction of BIBD, PBIBD, Youden square, Lattice Design. (**20 Hours**)

UNIT 4

Factorial Designs: Factorial designs - basic definitions and principles, two-factor factorial design – general factorial design, 2^k factorial design - Confounding and Partial Confounding, 3^2 - factorial, asymmetric factorial, two-level fractional factorial, Split Plot Design. (**20 Hours**)

UNIT 5 (Teacher Specific Module-Optional)

Advanced Topics: Connectedness and orthogonality of designs, Response surface designs, response surface methodology, first and second order designs. Analysis of real world problems using statistical software. (**10 Hours**)

TEXT BOOKS

1. Das, M.N. and Giri, N.S. (2002): ***Design and Analysis of Experiments*****,** 2nd Edition, New Age International (P) Ltd., New Delhi.
2. Joshi, D.D. (1987): ***Linear Estimation and Design of Experiments***. Wiley Eastern Ltd., New Delhi.
3. Montgomery, D.C. (2001): ***Design and Analysis of Experiments***. 5th Edition, John Wiley & Sons - New York.

SUGGESTED READINGS

1. Gupta, S.C. and Kapoor, V.K. (2010). ***Fundamentals of Applied Statistics*****.** Sulthan Chand & Co, New Delhi.
2. Dean, A. and Voss, A. (1999): ***Design and Analysis of Experiments*****.** Springer Verlag, New York.
3. Box, G.E.P. Hunter, W. (2005): ***Statistics for Experimental Design***, Innovations and Discovery, Vol. II, Wiley.

Semester IX

A24-28: -DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA506: GENERALIZED LINEAR MODELS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into the theory and applications of generalized linear models (GLMs), focusing on various advanced topics such as logistic regression, Poisson regression, log-linear models, zero-inflated models, and survival analysis. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of GLMs and their applications in analyzing complex data sets.

COURSE OBJECTIVES:

- Define and explain the key concepts of GLMs, including the exponential family of distributions, link functions, and model specification.
- Apply the method of maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate GLM parameters.
- Explore specialized GLM models such as Poisson regression and log-linear models for count data analysis.

- Apply GLMs to analyze hierarchical and longitudinal data using techniques such as generalized estimating equations (GEE) and mixed effects models.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying advanced GLM techniques such as logistic regression, Poisson regression, and log-linear models to analyze complex datasets.
CO2	Utilize maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate parameters in GLMs.
CO3	Apply GLMs to analyze count data using Poisson regression and handle excessive zeros using zero-inflated models.
CO4	Interpret GLM parameters and assess the significance of predictor variables in the context of the research question.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Generalized Linear Models: Overview of generalized linear models (GLM s), exponential family of distributions, link functions and model specification, logistic regression, comparison with linear regression and logistic regression, interpretation of GLM parameters, nominal and ordinal regression. **(15 Hours)**

UNIT 2

Model Estimation and Inference: Method of maximum likelihood estimation, iteratively reweighted least squares (IRLS) algorithm, model diagnostics: residual analysis, goodness-of-fit tests, confidence intervals and hypothesis testing for model parameters, overdispersion and model assessment. **(25 Hours)**

UNIT 3

Poisson Regression and Log-linear Models: Count data, Poisson regression, Estimation and model diagnostics, Contingency tables, log-linear models, Inference for log-linear models, Numerical examples, zero-inflated Poisson models. **(20 Hours)**

UNIT 4

Advanced Topics in GLMs: Generalized estimating equations (GEE), zero-inflated and negative binomial models, hierarchical GLM s and mixed effects models, time-to-event data analysis using GLM s (survival analysis), model selection techniques: AIC, BIC. **(20 Hours)**

UNIT 5

Applications of GLM s in biomedical research, epidemiology, and social sciences, case studies and real-world examples, practical implementation of GLM s using statistical software (R or SAS or SPSS). **(10 Hours)**

TEXT BOOKS

1. Dobson, A. J., & Barnett, A. G. (2018). ***An Introduction to Generalized Linear Models*** *(4th ed.)*. CRC Press.
2. McCullagh, P., & Nelder, J. A. (1989). ***Generalized Linear Models*** *(2nd ed.)*. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Faraway, J. J. (2006). ***Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models.*** Chapman and Hall/CRC.
2. Agresti, A. (2015). ***Foundations of Linear and Generalized Linear Models.*** John Wiley & Sons.
3. Hardin, J. W., & Hilbe, J. M. (2013). ***Generalized Linear Models and Extensions (3rd ed.).*** Stata Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester IX

A24-28-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA507 - ADVANCED TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA507	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of time series analysis, focusing on the analysis and modeling of data collected over time. Students will learn fundamental concepts, methods, and techniques for exploring, modeling, and forecasting time series data, with a particular emphasis on applications in various fields such as finance, economics, and engineering.

COURSE OBJECTIVES:

- Gain a thorough understanding of fundamental concepts in time series analysis, including stochastic processes, auto-covariance, auto-correlation, and spectral density.
- Learn techniques for exploratory time series analysis, including identifying trends, seasonality, and smoothing methods such as exponential and moving average smoothing.
- Understand autoregressive models (AR), moving average models (MA), autoregressive moving average models (ARMA), and autoregressive integrated moving average models (ARIMA).
- Learn about non-linear time series models, including spectral analysis, periodogram, and correlogram analysis.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understand exploratory time series analysis and its real data application.
CO2	Understand autoregressive models and their estimation methods.
CO3	Understand non-linear time series models and their estimation methods.
CO4	Apply statistical techniques to time series data and make predictions.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓		✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

COURSE CONTENTS

UNIT 1

Time Series Basic Concepts: Motivation, Time series as a discrete parameter stochastic process, Auto-Covariance, Auto-Correlation, and spectral density and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, Holt-Winters smoothing, forecasting based on smoothing, Adaptive smoothing. **(25 Hours)**

UNIT 2

Autoregressive Models: Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average, and Autoregressive Integrated Moving Average Models. Choice of AR/MA orders. Seasonal ARIMA models. **(15 Hours)**

UNIT 3

Estimation of ARMA and ARIMA Models: Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least square estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance, and autocorrelation function under large samples theory, residual analysis and diagnostic checking. Forecasting using ARIMA models.
(25 Hours)

UNIT 4

Non-Linear Time Series Models: Spectral analysis of weakly stationary processes. Periodogram and correlogram analysis. Introduction to financial time series, return series, special features of financial return series, volatility, volatility modeling, ARCH and GARCH models, properties and estimation. Introduction to stochastic volatility models, threshold autoregression. **(15 Hours)**

UNIT 5

Hands-on exercises using statistical software (e.g., R or Python) to implement advanced time series models. Analysis of real-world financial time series data using ARCH, GARCH, and stochastic volatility models. Interpretation of model outputs and forecast results.
(10 Hours)

TEXT BOOKS

1. Box G.E.P and Jenkins G.M. (1970). ***Time Series Analysis, Forecasting, and Control***. Holden-Day.
2. Brockwell P.J. and Davis R.A. (1987). ***Time Series: Theory and Methods***, Springer Verlag.

SUGGESTED READINGS

1. Abraham B. and Ledolter J.C. (1983). ***Statistical Methods for Forecasting***, Wiley.
2. Anderson T.W. (1971). ***Statistical Analysis of Time Series***, Wiley.
3. Fuller W.A. (1978). ***Introduction to Statistical Time Series***, John Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE -DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA501: OPERATIONS RESEARCH

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA501	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of operations research techniques and optimization methods, focusing on linear programming, duality, network analysis, integer programming, and game theory. Students will learn theoretical concepts and practical applications of these techniques in solving complex decision-making problems in various fields such as business, engineering, and management.

COURSE OBJECTIVES:

- Gain a deep understanding of linear programming problems (LPPs), including the algebraic formulation, graphical solution methods, and the concept of feasible, basic feasible, and optimum basic feasible solutions.
- Comprehend the duality concept in linear programming, including the formulation of dual problems, duality theorems, and the dual simplex method.
- Learn about network analysis, focusing on critical path analysis, the Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT). The distinction between CPM and PERT will be emphasized.
- Learn the fundamentals of game theory, including pure and mixed strategies, and the conversion of two-person zero-sum games into linear programming problems.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate proficiency in formulating linear programming problems (LPPs) and understanding their graphical solutions.
CO2	Understand the concept of duality in linear programming and apply duality theorems to formulate dual problems.
CO3	Apply cutting plane methods and the branch and bound technique to solve integer programming problems.
CO4	Analyze decision-making scenarios using game theory concepts, including pure and mixed strategies.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Algebra of linear programming problems: Introduction to linear programming problem (LPP), graphical solution, feasible, basic feasible, and optimum basic feasible solution to an LPP. Analytical results in general LPP, theoretical development of simplex method. (**15 Hours**)

UNIT 2

Duality and Dual Simplex Method: Artificial variables, Big-M method, two-phase simplex method. Duality, duality theorems, dual simplex methods. Transportation problem, assignment problem. (**10 Hours**)

UNIT 3

Integer Programming and Network Analysis: Integer programming: Cutting plane methods, branch and bound technique. Network analysis, Critical path analysis, -CPM, PERT, distinction between CPM and PERT. (**15 Hours**)

UNIT 4

Game Theory: Game theory, pure and mixed strategies, conversion of two-person zero-sum game into a linear programming problem. Solution to game through algebraic, graphical, and linear programming methods. (**10 Hours**)

UNIT 5

Sensitivity Analysis and Parametric Programming: Interpretation of shadow prices and sensitivity ranges, Application of sensitivity analysis in decision-making and risk management. (**10 Hours**)

TEXT BOOKS

1. K.V. Mital and Mohan, C (1996). ***Optimization Methods in Operations Research and Systems Analysis, 3rd Edition*****,** New Age International (Pvt.) Ltd.
2. Kanti Swamp, Gupta, P.K. and John, M.M. (1985): ***Operations Research***., Sultan Chand & Sons.

SUGGESTED READINGS

1. Hadley, G. (1964). ***Linear Programming***, Oxford & IBH Publishing Co, New Delhi.
2. Taha. H.A. (1982): ***Operation Research***, An Instruction, Macmillan.
3. Hiller F.S. And Lieberman, G.J. (1995). ***Introduction to Operations Research***, McGraw-Hill

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA502:NON-PARAMETRIC INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA502	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive introduction to non-parametric statistical methods, focusing on inference techniques that do not rely on assumptions about the underlying probability distributions. Through theoretical discussions and practical applications, students will learn about the advantages, limitations, and various non-parametric tests used for data analysis.

COURSE OBJECTIVES:

- Gain a solid understanding of the principles underlying non-parametric inference, including the rationale behind using distribution-free tests and resampling methods.

- Learn and be able to apply one-sample non-parametric tests, including the Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit, and tests for normality such as the Kolmogorov-Smirnov and Shapiro-Wilk tests.
- Proficiency in performing two-sample non-parametric tests, such as the Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, and Friedman test for multiple related samples.
- Learn about non-parametric methods for assessing association and correlation between variables, including Spearman's rank correlation coefficient, Kendall's tau rank correlation coefficient, chi-square test and Fisher's exact test for contingency tables, and rank-based measures of association such as Somers' D.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Understanding fundamental principles of non-parametric inference, including the rationale for using distribution-free tests and resampling methods.
CO2	Demonstrate proficiency in applying one-sample non-parametric tests, including the Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit, and tests for normality such as the Kolmogorov-Smirnov and Shapiro-Wilk tests.
CO3	Able to perform two-sample non-parametric tests, such as the Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, and Friedman test for multiple related samples.
CO4	Apply non-parametric statistical methods to analyze real-world datasets, identifying appropriate tests based on the characteristics of the data and interpreting the results in the context of the research question or problem at hand.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Non-parametric Methods: overview of non-parametric inference, advantages and limitations compared to parametric methods, distribution-free tests and their applications, resampling methods, permutation tests and bootstrapping.
(**15 Hours**)

UNIT 2

One-Sample Non-parametric Tests: Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit , Kolmogorov-Smirnov test, Shapiro-Wilk test for normality.
(15 Hours)

UNIT 3

Two-Sample Non-parametric Tests: Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, Friedman test for multiple related samples.
(**25 Hours**)

UNIT 4

Non-parametric Methods for Association and Correlation: Spearman's rank correlation coefficient, Kendall's tau rank correlation coefficient, non-parametric methods for contingency tables - chi-square test, Fisher's exact test, rank-based measures of association - Somers' D.

(25 Hours)

UNIT 5

Application of Non-parametric Methods in Real-world Data Analysis: Data preparation and exploration, one-sample non-parametric tests in practice, two-sample non-parametric tests and beyond. **(25 Hours)**

TEXT BOOKS

1. Daniel, W. W. (2010). ***Applied Nonparametric Statistics*** *(3rd ed.)*. Cengage Learning.
2. Gibbons, J. D., & Chakraborti, S. (2010). ***Nonparametric Statistical Inference*** *(5th ed.)*. CRC Press.

SUGGESTED READINGS

1. Hollander, M., & Wolfe, D. A. (1999). ***Nonparametric Statistical Methods*** *(2nd ed.)*. Wiley.
2. Conover, W. J. (1999). ***Practical Nonparametric Statistics*** *(3rd ed.)*. Wiley.
3. Siegel, S., & Castellan Jr, N. J. (1988). ***Nonparametric Statistics for the Behavioral Sciences*** *(2nd ed.)*. McGraw-Hill.
4. Hollander, M., & Wolfe, D. A. (1973). ***Nonparametric Statistical Methods***. Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA503:ANALYSIS OF FINANCIAL TIME SERIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA503	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of financial time series analysis, covering various models and techniques used in the analysis of asset returns, volatility modeling, high-frequency data analysis, and risk estimation. Through theoretical lectures, practical exercises, and hands-on applications using financial data, students will develop the skills necessary to analyze and model financial time series data effectively, making informed decisions in financial markets.

COURSE OBJECTIVES:

- Understanding Financial Time Series: Develop a comprehensive understanding of financial time series data, including the characteristics of asset returns, distributional properties, and the basic concepts of linear time series analysis, enabling students to effectively analyze and interpret financial data.
- Proficiency in Volatility Modeling: Gain proficiency in modeling volatility in financial time series using conditional heteroscedastic models, including ARCH, GARCH, and

stochastic volatility models, enabling students to accurately capture and forecast volatility dynamics in financial markets.

- Mastery of High-Frequency Data Analysis: Acquire mastery in analyzing high-frequency financial data, including nonsynchronous trading, bid-ask spread, and empirical characteristics of transactions data. Students will learn various models for price changes and duration models to effectively analyze high-frequency data.
- Proficiency in Risk Estimation: Develop proficiency in estimating extreme values and calculating Value at Risk (VaR), an essential risk measure in finance. Students will learn RiskMetrics, quantile estimation, quantile regression, extreme value theory, and multiperiod VaR, enabling them to assess and manage financial risk effectively.
- Application of Multivariate Time Series Analysis: For students who opt for the optional module, gain proficiency in multivariate time series analysis techniques such as vector autoregressive (VAR) models, impulse response functions, and vector moving-average (VMA) models, enabling students to analyze interdependencies among multiple financial variables effectively.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Demonstrate an advanced understanding of financial time series data, including its characteristics, distributional properties, and the application of linear time series analysis techniques, enabling them to analyze and interpret financial data effectively.
CO2	Acquire proficiency in modeling volatility in financial time series using conditional heteroscedastic models such as ARCH, GARCH, and stochastic volatility models. They will be able to accurately model and forecast volatility dynamics, enhancing their ability to make informed decisions in financial markets.
CO3	Master the analysis of high-frequency financial data, including nonsynchronous trading, bid-ask spread, and duration models, students will be equipped to effectively analyze and interpret high-frequency data and identify trading opportunities in financial markets.
CO4	Develop proficiency in estimating extreme values and calculating Value at Risk (VaR), an essential risk measure in finance. They will be able to assess and manage financial risk effectively, enhancing their ability to make informed risk management decisions in financial markets.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit- 1

Financial Time Series and Their Characteristics: Asset Returns, Distributional Properties of Returns, overview of Linear Time Series Analysis and Its Applications, Stationarity, Correlation and Autocorrelation Function, White Noise and Linear Time Series, Simple Autoregressive Models, Simple Moving-Average Models, Simple ARMA Models, Seasonal Models. **(20 Hours)**

Unit- 2

Conditional Heteroscedastic Models: Definition of volatility, Characteristics of Volatility, Structure of a Model, Testing for ARCH Effect, The ARCH Model, Properties of ARCH Models, Weaknesses of ARCH Models, Building an ARCH Model, The GARCH Model, The Integrated GARCH Model, The GARCH-M Model, The Exponential GARCH Model, The Stochastic Volatility Model. **(25 hours)**

Unit-3

High-Frequency Data Analysis: Nonsynchronous Trading, Bid–Ask Spread, Empirical Characteristics of Transactions Data, Models for Price Change-Ordered Probit Model, Duration Models, The ACD Mode, Simulation, Estimation, Nonlinear Duration Models. **(20 Hours)**

Unit -4

Extreme Values, Quantile Estimation, and Value at Risk: Value at Risk, RiskMetrics, An Econometric Approach to VaR Calculation, Quantile and Order Statistics, Quantile

Regression, Extreme Value Theory, Extreme Value Approach to VaR, Multiperiod VaR, VaR for a Short Position, Use of Explanatory Variables, Model Checking. **(20Hours)**

Unit-5 (Teacher Specific module-Optional)

Multivariate Time Series Analysis and Its Applications: Weak Stationarity and Cross-Correlation Matrices, Sample Cross-Correlation Matrices, Multivariate Portmanteau Tests, Vector Autoregressive Models, Impulse Response Function, Vector Moving-Average Model, Vector ARMA Models. **(20 Hours)**

TEXT BOOKS

1. Tsay, R. S. (2005). ***Analysis of Financial Time Series.*** John wiley & sons..
2. Tsay, R. S. (2014). ***An Introduction to Analysis of Financial Data with R***. John Wiley & Sons.

SUGGESTED READINGS

1. Tsay, R. S. (2013). ***Multivariate Time Series Analysis: with R and Financial Applications.*** John Wiley & Sons.
2. Tsay, R. S., & Chen, R. (2018). ***Nonlinear Time Series Analysis*** . John Wiley & Sons..

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA504 - CATEGORICAL DATA ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA504	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of advanced statistical models for analyzing longitudinal and categorical data. Students will learn theoretical concepts and practical applications of generalized linear models, logistic regression, log-linear models, and mixed-effects models. Through lectures, discussions, and hands-on exercises, students will develop the skills necessary to analyze complex data sets, make inferences, and interpret results effectively.

COURSE OBJECTIVES:

- Conduct analysis of longitudinal data.
- Apply statistical techniques to model longitudinal data and make predictions.
- Understand analysis of longitudinal data with missing data.
- Understand analysis of longitudinal data with time-dependent covariates

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Define categorical data and identify appropriate measures for analysis.
CO2	Utilize logistic regression and logit models to analyze categorical predictors.
CO3	Understand and apply general linear mixed-effects models for longitudinal data analysis, including inference for random effects.
CO4	Understand and address issues related to missing data mechanisms and dropout processes in longitudinal studies.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Categorical Data Analysis and Generalized Linear Models: Categorical data and their measures, Inference for contingency tables, Generalized linear models for binary and count data. Estimation, Inference and fitting of model. **(15 Hours)**

UNIT 2

Logistic Regression with Categorical Predictors: Logistic, logit and log linear models with categorical predictors, Logit models with multi responses- Nominal and ordinal responses. **(15 Hours)**

UNIT 3

Longitudinal Data Analysis and General Linear Mixed Models: Longitudinal data and their characteristics, The general linear model for longitudinal data-ML and REML estimation, EM algorithm, General linear mixed effect model. Inference for the random effects. BLUPs, Empirical bayes, Shrinkage model building and diagnostics, Generalised additive mixed model. **(25 Hours)**

UNIT 4

Advanced Models for Longitudinal Data Analysis: Generalized linear model for longitudinal data, Random effect model, Transition models, Poisson and logistic regression models, Analysis and test. Classification of missing data mechanism-intermittent missing values and dropouts, weighted estimating equations, Modelling the drop out process. (**25 Hours**)

UNIT 5

Practical Application: Hands-on exercises using statistical software R, Analyzing real-world datasets, Model estimation, interpretation, and diagnostics. (**10 Hours**)

TEXT BOOKS

1. Agresti, A. (2012). ***Categorical Data Analysis*** (Vol. 792). John Wiley & Sons.
2. Diggle, P.J, Heagerty, P., Liang, K.,Y & Zeger,S.,I (2003), ***Analysis of Longitudinal Data***, Oxford university press.
3. Lindsey, J.,K.(1993)**.** ***Models for Repeated Measurements***, Oxford

SUGGESTED READINGS

1. Weiss, R., E.(2005), ***Modeling Longitudinal Data***, Springer, New York.
2. Little, R. J. A. & Rubin, D., B(2002), ***Statistical Analysis with Missing Data***, Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA505 - MIXTURE REGRESSION MODELS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA505	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of mixture distributions and models in statistics. Students will learn theoretical concepts, simulation techniques, estimation methods, and practical applications of finite and infinite mixture models. Through lectures, hands-on exercises, and real-world examples, students will gain proficiency in analyzing complex data sets using mixture models and related statistical methodologies.

COURSE OBJECTIVES:

- Learn simulation techniques for generating random samples from finite normal, Poisson, and negative binomial mixtures.
- Study normal mixture regression and Poisson mixture regression models.
- Apply mixture regression models to real and simulated data using statistical software packages such as R and relevant libraries like FlexMix, Mixtools, and CAMAN.
- Explore examples of generalized linear mixture models, including logistic and mixture logistic models.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Identify the characteristics and properties of location and scale mixtures.
CO2	Simulate random samples from finite normal, Poisson, and negative binomial mixtures.
CO3	Estimate parameters of mixture regression models using appropriate techniques.
CO4	Apply generalized linear mixture models, including logistic and mixture logistic models.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Mixture Distributions: Finite and infinite mixtures, location and scale mixtures, non-identifiable mixtures, examples of non-identifiable mixtures, condition for identifiability when the components belong to power series family. (**20 Hours**)

UNIT 2

Simulation and Estimation: Finite normal, Poisson and negative binomial mixtures, simulation of random samples from mixtures, applications of mixture models. Estimation of parameters of mixture models, method of moments, maximum likelihood estimation, EM algorithm. (**25 Hours**)

UNIT 3

Mixture Regression: Normal mixture regression, Poisson mixture regression, estimation of parameters, examples using real and simulated data, R-packages, FlexMix, Mixtools, and CAMAN. (**20 Hours**)

UNIT 4

Generalized Linear Mixture Models: Exponential family, generalized linear models, examples, generalized linear mixture models, logistic and mixture logistic models, concomitant variables and varying parameter cases.
(**15 Hours**)

UNIT 5

Bayesian Estimation for Mixture Models: Introduction to Bayesian mixture models, prior specification for mixture model parameters, Markov Chain Monte Carlo (MCMC) methods for Bayesian inference. (**10 Hours**)

TEXT BOOKS

1. McLachlan, G.J. and Peel, D. (2000). **Finite Mixture Models**. John Wiley & Sons, INC, New York.

SUGGESTED READINGS

1. Schlattmann, P. (2009). **Medical Applications of Finite Mixture Models.** Springer Verlag Berlin Heidelberg.
2. Titterington, D.M., Smith, A. and Makov, U. (1985). **Statistical Analysis of Finite Mixture Distributions**. New York: Wiley.
3. Leisch, F. (2004). **Flex Mix: A general framework for finite mixture models and latent class regression in R.** Journal of Statistical Software, 11(8), 1-18. http://www.jstatsoft.org/
4. Wang, P. et al. (1996). **Mixed Poisson regression models with covariate dependent rates**. Biometrics, 52, 381-400.
5. Sapatinas, T. (1995). **Identifiability of mixtures of power-series distributions and related characterizations**. Ann. Inst. Statist. Math., 47(3), 447-459.
6. McLachlan, G.J. and Krishnan, T. (1997). **The EM algorithm and Extensions.** New York: Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA506-ANALYSIS OF DISCRETE AND LONGITUDINAL DATA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into advanced statistical methodologies for analyzing longitudinal data, focusing on discrete outcomes, generalized linear models, missing data mechanisms, time-dependent covariates, and special topics in longitudinal data analysis. Through theoretical concepts, practical applications, and case studies, students will develop proficiency in modeling longitudinal data and addressing complex research questions in various fields.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of advanced statistical techniques for analyzing longitudinal data, including generalized linear models, random effects models, transition models, and likelihood-based models for categorical data.
- Learn to classify missing data mechanisms, address intermittent missing values and dropouts, and implement weighted estimating equations and modeling techniques for the dropout process.
- Recognize the challenges associated with time-dependent covariates, implement lagged covariates, and apply marginal structural models to account for time-varying confounding factors.
- Gain insight into specialized topics such as joint models for longitudinal and survival data, multivariate longitudinal data analysis, and the design of randomized and observational longitudinal studies.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Conduct analysis of longitudinal data.
CO2	Apply statistical techniques to model longitudinal data and make predictions.
CO3	Understand analysis of longitudinal data with missing data.
CO4	Understand analysis of longitudinal data with time-dependent covariates.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	
CO4	✓		✓	✓	✓

COURSE CONTENTS

UNIT 1

Discrete Data and their Measures: Inference for contingency tables, Logistic models, statistical power and sample size computations Logit models with categorical predictors, logit models with multi responses-nominal and ordinal responses.

UNIT 2

Generalized Linear Model for Longitudinal Data: Generalized Linear Model for Longitudinal Data, Marginal models, for binary, ordinal, and count data: Random effects models for binary and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses.

UNIT 3

Longitudinal Data with Missing Data: Classification missing data mechanism; Intermittent missing values and dropouts; Weighted estimating equations; Modeling the dropout process (Selection and pattern mixture models).

UNIT 4

Time-dependent Covariates and Special Topics: Dangers of time-dependent covariates, Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies.

UNIT 5

Exploratory Data Analysis, Modeling Approaches: Students will apply various modeling approaches discussed in earlier units, such as Generalized Linear Models (GLMs), Generalized Estimating Equations (GEE), and Marginal Structural Models (MSMs), to analyze longitudinal data using statistical software.

TEXT BOOKS

1. Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). ***Analysis of Longitudinal Data***, 2nd Edn. Oxford University Press, New York.
2. Fitzmaurice, G.M., Laird, N.M and Ware, J.H. (2004). ***Applied Longitudinal Analysis***, John Wiley & Sons, New York.

SUGGESTED READINGS

1. Crowder, M.J. and Hand, D.J. (1990). ***Analysis of Repeated Measures.*** Chapman and Hall/CRC Press, London.
2. Davidian, M. and Giltinan, D.M. (1995). ***Nonlinear Models for Repeated Measurement Data***. Chapman and Hall/CRC Press, London.
3. Hand, D. and Crowder, M. (1996). ***Practical Longitudinal Data Analysis.*** Chapman and Hall/CRC Press, New York.
4. McCullagh, P. and Nelder. J. A. (1989). ***Generalized Linear Models. 2nd Edition***, Chapman and Hall/CRC Press, London.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA507-ADVANCED QUEUEING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA507	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of queueing theory and its practical applications in various systems. Divided into four units, the course covers a range of topics from introductory concepts to advanced models, equipping students with the knowledge and skills to analyze and optimize queueing systems effectively. Through lectures, practical exercises, and case studies, students will gain a deep understanding of queueing theory and develop the analytical skills necessary to address complex queueing problems in various domains, including telecommunications, computer systems, manufacturing, and service industries.

COURSE OBJECTIVES:

- Understanding Queueing Theory Fundamentals: Gain a comprehensive understanding of the fundamental concepts and terminology of queueing theory, including arrival processes, service patterns, queueing disciplines, and system performance metrics.
- Mastering Markovian Queueing Models: Develop proficiency in analyzing Markovian queueing models, including the M/M/1 model, and deriving steady-state solutions.
- Exploring Advanced Queueing Models: Explore advanced Markovian queueing models, including transient behavior analysis, busy period analysis for M/M/1 and M/M/c models, and Erlangian models.
- Analyzing Queueing Networks: Learn how to analyze various types of queueing networks, such as series queues, open and closed Jackson networks, cyclic queues, and extensions of Jackson networks.
- Mastering Non-Markovian Queueing Models: Develop proficiency in analyzing non-Markovian queueing models, including models with general service patterns, M/G/1 queueing models, and the Pollaczek-Khintchine formula.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of the fundamental principles, concepts, and terminology of queueing theory, including arrival processes, service patterns, queueing disciplines, and system performance metrics.
CO2	Gain proficiency in analyzing both Markovian and non-Markovian queueing models, including steady-state solutions, waiting-time distributions, and system performance metrics..
CO3	Learn how to analyze various types of queueing networks, including series queues, Jackson networks, cyclic queues, and non-Jackson networks.
CO4	Apply queueing theory concepts and techniques to analyze and optimize real-world systems in various domains, including telecommunications, computer systems, manufacturing, and service industries.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit 1

Markovian Queueing Models: Introduction to queueing theory, Characteristics of queueing processes, Measures of effectiveness, Markovian queueing models, steady-state solutions of the M/M/1 model, waiting-time distributions, Little's formula, queues with unlimited service, finite source queues. **(15 Hours)**

Unit 2

Advanced Markovian Models: Transient behavior of M/M/1 queues, transient behavior of M/M/1. Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models.

Bulk input M[X]/M/1 model, Bulk service M/M[Y]/1 model, Erlangian models, M/Ek/1 and Ek/M/1. A brief discussion of priority queues. **(25 Hours)**

Unit 3

Queueing Networks: Series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non-Jackson networks. **(15 Hours)**

Unit 4

Non-Markovian Queueing Models: Models with general service pattern, The M/G/1 queueing model, The Pollaczek-Khintchine formula, Departure point steady state system size probabilities, ergodic theory, Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities. **(25 Hours)**

Unit 5 (Teacher Specific Module-Optional)

Advanced queuing models, Bayesian estimation in queueing models. **(10 Hours)**

Books for Study:

1. Gross, D. and Harris, C.M. (1985): ***Fundamentals of Queueing Theor***y, 2nd Edition, John Wiley and Sons, New York.

Reference Books:

1. Ross, S.M. (2010). ***Introduction to Probability Models***. 10th Edition, Academic Press, New York.
2. Bose, S.K. (2002). ***An Introduction to Queueing Systems*****,** Kluwer Academic/Plenum Publishers, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

MODE OF TRANSACTION

- Direct class room, Lecture, Seminar, Discussion, ICT based lecture,

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA508:HEALTH ECONOMICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA508	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3		1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers an in-depth exploration of the intersection between economics and healthcare, focusing on the principles, policies, and practices that shape the delivery, financing, and regulation of healthcare systems. Through theoretical frameworks, empirical analysis, and case studies, students will gain a comprehensive understanding of health economics and its implications for healthcare markets, financing, delivery, and policy.

COURSE OBJECTIVES:

- Define health economics and its scope within the broader field of economics.

- Examine the structure of healthcare markets, including public, private, and mixed systems.
- Understand healthcare production and efficiency, including production functions, economies of scale, and scope.
- Conduct health policy analysis, including defining policy objectives, evaluating policy tools, and criteria for policy evaluation.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Apply key economic concepts such as scarcity, opportunity cost, efficiency, and equity to healthcare contexts.
CO2	Analyze various health insurance and financing mechanisms, including fee-for-service, capitation, and social health insurance.
CO3	Analyze provider behavior and its impact on healthcare delivery, including physician incentives and moral hazard.
CO4	Conduct health policy analysis, including defining policy objectives, evaluating policy tools, and criteria for policy evaluation.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Introduction to Health Economics: Overview of health economics: Definition, scope, and importance, Basic economic concepts in healthcare: Scarcity, opportunity cost, efficiency, and equity. Theoretical frameworks: Supply and demand, market failure, and role of government intervention. Economic evaluation methods: Cost-benefit analysis, cost-effectiveness analysis, and cost-utility analysis.
(**15 Hours**)

UNIT 2

Healthcare Markets and Financing: Structure of healthcare markets: Public, private, and mixed systems. Health insurance and financing mechanisms: Fee-for-service, capitation, health savings accounts, and social health insurance. Equity and access: Healthcare disparities, barriers to access, and policies for addressing inequality. Pharmaceutical economics: Drug pricing, reimbursement mechanisms, and pharmaceutical regulation. (**15 Hours**)

UNIT 3

Healthcare Delivery and Organization: Healthcare production and efficiency: Production functions, economies of scale, and scope. Provider behavior: Physician incentives, supplier-induced demand, and moral hazard. Hospital economics: Cost structure, payment systems, and competition among providers. Quality and performance measurement: Value-based purchasing, pay-for-performance, and quality improvement initiatives. (**15 Hours**)

UNIT 4

Health Policy and Regulation: Health policy analysis: Policy objectives, tools, and evaluation criteria. Regulation and market interventions: Certificate of need, price controls, and antitrust policies. Health technology assessment: Assessment of new medical technologies and devices. Global health economics: Comparative healthcare systems, health disparities, and international health policy. (**10 Hours**)

UNIT 5

Health sector reforms- International and Indian experiences regulation of health sector including pharmaceutical industry access to health care with quality health care utilization. (**5 Hours**)

TEXT BOOKS

1. Banerjee D. (1982) ***Poverty class and Health Culture in India Vol. 1*** *ParchiPrakashan* New Delhi.
2. Indian Council of Social Science Research and Indian Council of Medical Research (1981) *Health for All by 2000 A. D.* ICSSR Delhi.

SUGGESTED READINGS

1. Madan T.N. (1969). ***Who Chooses Modern Medicine and Why" Economic and Political*** *Weekly pp.* 1475-84.
2. Feldstein M.S. (1977). ***Economic analysis of Health Service Efficiency*** *North-Holland Amsterdam.*
3. Cutler and Zeckhauser (1999). ***The Anatomy of Health Insurance NBER Working Paper*** 7176.
4. Levy and Deleire (2002). ***What do People Buy When They Don't Buy Health Insurance.*** *Working Paper* Harris School University of Chicago.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA509- LIFE CONTINGENCIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA509	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
3	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive examination of mortality analysis, population dynamics, insurance contracts, and risk assessment techniques within the context of actuarial science. Students will explore various models, theories, and methods used in the insurance industry to assess risk, calculate premiums, and ensure financial stability. Through theoretical discussions, practical applications, and case studies, students will gain a deep understanding of actuarial principles and their applications in insurance and pension schemes.

COURSE OBJECTIVES:

- Understanding Mortality Analysis and Models.
- Mastery of Assurance and Annuity Contracts.
- Proficiency in Modeling Cash Flows and Risks.
- Analysis of Heterogeneity in Mortality and Risk Classification.

COURSE OUTCOMES:

After successful completion of this course, students will be able to understand:

SL #	Course Outcomes
CO1	Analyze mortality data and apply appropriate models for mortality analysis.
CO2	Adjust net premiums and provisions for changing benefits and annuities.
CO3	Identify contributing factors to heterogeneity in mortality and its implications for risk assessment.
CO4	Analyze the financial implications of guarantees on the stability and profitability of insurance products.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

UNIT 1

Mortality analysis and models: Population growth, composition and distribution, Projection models, Stable population theory, Life tables and its relation with survival function, force of mortality, various conditional probabilities from ultimate and select life tables, monthly payments, inter-relations of various types of payments. Calculation of various probabilities from life tables, approximations, select and ultimate tables, alternatives to life tables.Calculation of various payments from life tables: principle of equivalence, net premiums, prospective and retrospective provisions/reserves, recursive relations, Thiele's equation, actual and expected death strain, mortality profit/loss.
(**15 Hours**)

UNIT 2

Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments,Adjustment of net premium/net premium provisions for increasing/decreasing benefits and annuities, calculations with ultimate or select mortality, with-profits contract and allied bonus, net premium provision. Gross premiums-Various expenses, role of inflation, future loss and equivalence principle, alternative principles, calculation of gross premium provisions, gross premium retrospective provisions, recursive relations. (**10 Hours**)

UNIT 3

Functions of two lives: cash-flows contingent on death/survival of either or both of two lives, functions dependent on a fixed term and on age. Cash-flow models for competing risksMarkov model, dependent probability calculations from Kolmogorov equations, transition intensities. Use of discounted emerging costs in pricing, reserving and assessing profitability: unit-linked contract, expected cash flows for various assurances and annuities, profit tests and profit vector, profit signature, net present value and profit margin, use of profit test in product pricing and determining provisions, multiple decrement tables, cash-flows contingent on multiple decrement, alternatives to multiple decrement tables, cash-flows contingent on nonhuman life risks.

(**15 Hours**)

UNIT 4

Heterogeneity in mortality: contributing factors, main forms of selection, selection in insurance contracts and pension schemes, selective effects of decrements, risk classification in 25 insurance, role of genetic information, single figure index, crude index, direct/indirect standardization, standardized mortality/morbidity ratio (SMR). Cost of guarantees: types of guarantees and options for long term insurance contracts, calculation through option-pricing and stochastic simulation.
(**10 Hours**)

UNIT 5

Introduction to Actuarial Modeling: Importance of risk assessment and management in insurance and pension industries.Role of actuaries in analyzing mortality, longevity, and financial risks.

(**10 Hours**)

TEXT BOOKS

1. P.M. Booth, R.G. Chadburn, D.R. Cooper, S. Haberman and D.E. James, (1999): ***Modern Actuarial Theory and Practice***, Chapman & Hall.
2. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones, and C.J. Nesbitt (1997): ***Actuarial Mathematics*** (2nd ed), Society of Actuaries.

SUGGESTED READINGS

1. B. Benjamin and J.H. Pollard 1993.***The Analysis of Mortality and Other Actuarial Statistics***, 3rd ed., Institute of Actuaries and Faculty of Actuaries.
2. Neill, Heinemann, (1977):***Life Contingencies.***

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Team Learning

ASSESSMENT RUBRICS

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 4 credit courses with 3 Credit Theory + 1 Credit Practical.

SKILL ENHANCEMENT COURSES (SEC)

Semester IV

DSE-SKILL ENHANCEMENT COURSE

KU4SECSTA201- DATA ANALYSIS USING EXCEL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU4SECSTA201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course is designed to provide students with a comprehensive understanding of Microsoft Excel and its applications in data analysis. Divided into four modules, the course covers essential Excel functionalities, mathematical and statistical functions, data visualization techniques, and advanced data analysis tools. Through a combination of lectures, hands-on exercises, and practical examples, students will gain proficiency in using Excel for data analysis and visualization. By the end of the course, students will be equipped with the skills and knowledge needed to effectively analyze and interpret data using Excel software.

COURSE OBJECTIVES:

- Mastering Excel Fundamentals: Develop a solid understanding of Excel basics, including navigating the interface, working with cells and ranges, and utilizing basic mathematical and statistical functions.
- Advanced Functionality Proficiency: Learn advanced Excel functions such as MIN, MAX, TRIM, LOWER, UPPER, PROPER, LEFT, RIGHT, MID, EXACT, RANDBETWEEN, RAND, LEN, SQRT, and IF function.
- Data Visualization Mastery: Acquire skills in creating a wide range of visualizations in Excel, including pie charts, bar charts, histograms, scatter plots, and box plots.
- Advanced Data Analysis Techniques:Learn advanced data analysis techniques such as calculating median, mode, standard deviation, and correlation coefficients in Excel.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate proficiency in navigating the Excel interface, organizing data effectively, and utilizing a wide range of Excel functions and features for data manipulation and analysis..
CO2	Develop advanced data analysis skills, including the ability to perform complex calculations, analyze statistical measures, and interpret data trends using Excel's built-in functions and tools.
CO3	Acquire proficiency in creating various types of charts and graphs in Excel to visually represent and communicate data insights effectively.
CO4	Leverage Excel as a tool for informed decision-making by analyzing data, identifying patterns and trends, and deriving actionable insights to support organizational or personal goals.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS:

Module 1:

Excel Introduction, Basic Navigation Tab, Concept of Cell and Cell address , row Column concept, Basic mathematical and statistical functions in Excel. (15 Hours)

Module 2:

Min, Max, Trim, Lower, Upper, Proper, Left, Right, Mid Exact, Randbetween, Rand, Len (Length of character) Paste special, SQRT, If function with Example of IF, More function like And, OR with their example, Conditional Formatting basic and advance level with OR, AND, Nested IF function, Index, Offset, Match. (15 Hours)

Module 3:

Graphics in excel-pie chart, bar chart, multiple bar diagram, sub-divided bar diagram, histogram, line chart, scatter diagram, box plot. (15 Hours)

Module 4:

Median, Mode, Standard Deviation (SD), Correlation, Large, Small, Pivot Table, Pivot Charts, Slicing, Sparkling. (15 Hours)

Suggested Readings:

1. Linoff, Gordon S (2015). *Data analysis using SQL and Excel*. John Wiley & Sons.
2. Guerrero, Hector, Rauscher Guerrero, and Rauscher (2019). *Excel data analysis*. Springer International Publishing.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

DSE-SKILL ENHANCEMENT COURSE

KU4SECSTA202- DATA ANALYSIS USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU4SECSTA202	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of data analysis techniques using SPSS (Statistical Package for the Social Sciences). Divided into four modules, the course covers fundamental to advanced concepts of data analysis, including descriptive statistics, regression analysis, hypothesis testing, and data visualization. Through a combination of lectures, hands-on exercises, and practical examples, students will develop proficiency in utilizing SPSS for data analysis and interpretation.

COURSE OBJECTIVES:

- Understanding SPSS Basics: Introduce students to SPSS software, including its interface, functionalities, and data input methods.
- Descriptive Statistics: Teach students how to explore and summarize data using descriptive statistics in SPSS.
- Regression Analysis: Familiarize students with regression analysis techniques, including simple and multiple linear regression, and their application in SPSS.
- Hypothesis Testing: Enable students to perform hypothesis tests and interpret results using SPSS.
- Data Visualization: Develop skills in creating visualizations to effectively communicate data insights using SPSS.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Navigate the SPSS interface, input data, and perform basic operations for data analysis.
CO2	Conduct descriptive statistics analysis to summarize and interpret data distributions in SPSS.
CO3	Perform regression analysis in SPSS, interpret output, and assess model fit.
CO4	Conduct hypothesis tests using SPSS and interpret results effectively.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓
CO4	✓	✓	✓	✓	

COURSE CONTENTS:

Module 1

Overview of SPSS software, Opening SPSS, Layout of SPSS,Structure of SPSS Exiting SPSS, inputting data, An overview of SPSS. **(15 Hours)**

Module 2

Exploring data distributions using descriptive statistics, Creating frequency distributions and summary tables, Generating basic visualizations (e.g., histograms, box plots) in SPSS. **(15 Hours)**

Module 3

Understanding correlation and covariance, Performing correlation analysis in SPSS, Introduction to linear regression and its application in SPSS,Understanding hypothesis testing principles, Conducting hypothesis tests in SPSS, Interpreting SPSS output for hypothesis testing. **(15 Hours)**

Module 4

Generating various types of charts and graphs in SPSS, Customizing visualizations for clarity and impact, Exploring the SPSS Chart Builder tool. **(15 Hours)**

Suggested Readings:

1. Landau, S., & Everitt, B. S. (2003). *A handbook of statistical analyses using SPSS*. Chapman and Hall/CRC.
2. Tukey, J. W. (1977). *Exploratory data analysis* (Vol. 2, pp. 131-160).
3. Aldrich, J. O. (2018). *Using IBM SPSS statistics: An interactive hands-on approach*. Sage Publications.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

DSE-SKILL ENHANCEMENT COURSE

KU5SECSTA301- BASIC STATISTICS USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU5SECSTA301	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers an introduction to basic statistics using the R programming language. Divided into four modules, the course covers foundational statistical concepts, data manipulation, visualization, and hypothesis testing using R. Through lectures, hands-on exercises, and practical examples, students will gain proficiency in performing statistical analysis and interpreting results using R.

COURSE OBJECTIVES:

- Foundational Statistical Concepts: Introduce students to basic statistical concepts such as measures of central tendency, dispersion, and probability distributions using R.
- Data Manipulation and Visualization: Teach students how to manipulate and visualize data using R packages like dplyr, ggplot2, and base R plotting functions.
- Hypothesis Testing: Enable students to perform hypothesis tests for means, proportions, and variances using R.
- Statistical Inference: Familiarize students with confidence intervals and p-values, and their interpretation in the context of statistical inference using R.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand basic statistical concepts and their implementation in R.
CO2	Manipulate and visualize data using R packages for data manipulation and visualization.
CO3	Perform hypothesis tests and interpret results using R.
CO4	Apply statistical inference techniques and interpret confidence intervals and p-values using R.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓		✓

COURSE CONTENTS:

Module 1

Introduction to R and RStudio, Basic data types and data structures in R, Descriptive statistics: measures of central tendency and dispersion, Probability distributions in R (e.g., normal distribution, binomial distribution) **(15 Hours)**

Module 2

Data manipulation with dplyr package, Data visualization, Creating basic plots using base R plotting functions, Customizing plots for clarity and impact . **(15 Hours)**

Module 3

Introduction to hypothesis testing: null and alternative hypotheses, One-sample and two-sample t-tests in R, Chi-square test for independence, Z-test for proportions. **(15 Hours)**

Module 4

Confidence intervals for means and proportions, Interpreting p-values and making conclusions, Introduction to linear regression in R, Assessing model fit and interpreting regression output. **(15 Hours)**

Suggested Readings:

1. Kabacoff, R. I. (2015). ***R in Action: Data Analysis and Graphics with R*** (2nd ed.). Manning Publications.
2. Crawley, M. J. (2013). ***The R Book***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

DSE-SKILL ENHANCEMENT COURSE

KU5SECSTA302- STATISTICAL DATA VISUALIZATION AND GRAPHICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU5SECSTA302	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on statistical data visualization and graphics techniques using various tools and programming languages. Divided into four modules, the course covers foundational principles of data visualization, commonly used visualization techniques, interactive visualization, and advanced graphics customization. Through lectures, practical demonstrations, and hands-on exercises, students will develop proficiency in creating informative and visually appealing statistical graphics.

COURSE OBJECTIVES:

- Foundational Principles of Data Visualization: Introduce students to the principles and importance of effective data visualization in statistical analysis.
- Commonly Used Visualization Techniques: Teach students how to create and interpret common statistical plots such as histograms, box plots, scatter plots, and bar plots.
- Interactive Visualization: Enable students to create interactive visualizations using tools like Plotly, Bokeh, or JavaScript libraries.
- Advanced Graphics Customization: Familiarize students with advanced customization techniques to enhance the clarity and impact of statistical graphics.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand the principles of effective data visualization and its importance in statistical analysis.
CO2	Create and interpret commonly used statistical plots such as histograms, box plots, scatter plots, and bar plots.
CO3	Develop interactive visualizations using tools like Plotly, Bokeh, or JavaScript libraries.
CO4	Apply advanced customization techniques to enhance the clarity and impact of statistical graphics.

MAPPING OF COs to PSOs

SI No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓
CO3	✓	✓	✓		✓
CO4	✓		✓	✓	✓

COURSE CONTENTS:

Module 1

Introduction to data visualization and its importance, Principles of effective data visualization, Choosing the right visualization for different types of data. **(15 Hours)**

Module 2

Histograms and density plots, Box plots and violin plots, Scatter plots and bubble charts, Bar plots and pie charts. **(15 Hours)**

Module 3

Introduction to interactive visualization tools, Creating interactive plots using Plotly, Interactive graphics with Bokeh, Introduction to JavaScript libraries for data visualization. **(15 Hours)**

Module 4

Customizing plot aesthetics: colors, fonts, and labels, Adding annotations and text to plots, Enhancing plots with themes and templates, Creating animated and dynamic visualizations. **(15 Hours)**

Suggested Readings:

1. Wickham, H., & Grolemund, G. (2016). R for Data Science. O'Reilly Media.
2. Healy, K. (2018). Data Visualization: A Practical Introduction. Princeton University Press.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

DSE-SKILL ENHANCEMENT COURSE

KU6SECSTA303- STATISTICAL REPORTING AND INTERPRETATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	200	KU6SECSTA303	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on statistical reporting and interpretation techniques, providing students with the skills to effectively communicate statistical findings to diverse audiences. Divided into four modules, the course covers principles of statistical reporting, best practices for presenting statistical results, interpreting statistical output, and communicating findings through written reports and presentations. Through lectures, practical exercises, and case studies, students will learn how to convey statistical information accurately and persuasively.

COURSE OBJECTIVES:

- Principles of Statistical Reporting: Introduce students to the principles and standards of statistical reporting, including clarity, accuracy, and transparency.
- Best Practices for Presenting Statistical Results: Teach students best practices for presenting statistical results in written reports and oral presentations.
- Interpreting Statistical Output: Enable students to interpret statistical output from various analyses, including hypothesis tests, regression models, and data visualizations.
- Communicating Findings: Provide students with the skills to effectively communicate statistical findings to diverse audiences through clear and compelling written reports and presentations.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand the principles and standards of statistical reporting.
CO2	Apply best practices for presenting statistical results in written reports and oral presentations.
CO3	Interpret statistical output from various analyses accurately and effectively.
CO4	Communicate statistical findings to diverse audiences through clear and compelling written reports and presentations.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS:

Module 1

Introduction to statistical reporting standards and guidelines, Principles of clarity, accuracy, and transparency in statistical reporting, Ethical considerations in statistical reporting. **(15 Hours)**

Module 2

Structuring written reports: introduction, methods, results, discussion, conclusion, Creating effective visualizations to support statistical findings, Best practices for designing slides and delivering oral presentations. **(15 Hours)**

Module 3

Interpreting output from hypothesis tests, including p-values and confidence intervals, Interpreting output from regression models, including coefficients and goodness-of-fit measures, Interpreting output from data visualizations, including identifying trends and patterns. **(15 Hours)**

Module 4

Writing clear and concise summaries of statistical findings, Designing effective tables and figures to illustrate statistical results, Tips for delivering persuasive presentations and addressing audience questions. **(15 Hours)**

Suggested Readings:

1. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. John Wiley & Sons.
2. Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics. SAGE Publications Ltd.

TEACHING LEARNING STRATEGIES

Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

DSE-SKILL ENHANCEMENT COURSE

KU6SECSTA304- DATA ANALYSIS USING SAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	200	KU6SECSTA304	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of data analysis techniques using the SAS software suite. Students will learn how to import, manipulate, analyze, and visualize data using SAS programming language. Through hands-on exercises and real-world applications, students will gain proficiency in data cleaning, transformation, exploratory data analysis (EDA), statistical analysis, and predictive modeling using SAS.

COURSE OBJECTIVES:

- Mastering SAS Environment: Equip students with the necessary skills to navigate and utilize the SAS software suite effectively, fostering confidence and proficiency in its usage.
- Data Handling Proficiency: Enable students to proficiently import, clean, and preprocess diverse datasets within SAS, ensuring data integrity and reliability for subsequent analysis.
- Exploratory Data Analysis (EDA): Cultivate students' ability to conduct thorough exploratory data analysis, empowering them to extract meaningful insights and identify patterns or trends within datasets using SAS tools and techniques
- Statistical Analysis Competence: Develop students' competency in applying basic and advanced statistical analysis techniques within SAS, enabling them to derive robust conclusions and make data-driven decisions.
- Predictive Modeling Skills: Provide students with the knowledge and skills to build predictive models using SAS, allowing them to forecast future trends, make informed predictions, and optimize decision-making processes

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Demonstrate proficiency in navigating and utilizing the SAS software suite, employing various tools and functionalities to import, manipulate, analyze, and visualize data effectively.
CO2	Exhibit competency in performing comprehensive data analysis tasks, including data cleaning, transformation, exploratory data analysis (EDA), statistical analysis, and predictive modeling using SAS programming language.
CO3	Develop critical thinking skills and the ability to approach complex data analysis problems systematically, applying appropriate SAS techniques, methodologies, and statistical tools to derive actionable insights and solutions.
CO4	Communicate their data analysis findings and insights effectively through clear and concise reports, visualizations, and presentations, demonstrating their ability to translate technical analyses into meaningful and actionable information for diverse stakeholders.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1

Introduction to SAS and Data Import: Overview of SAS software and its applications, Installation and setup of SAS environment, Importing data from various sources, Cleaning and preprocessing data in SAS. **(15 Hours)**

Module 2

Data Manipulation and Transformation: Working with SAS datasets and data steps, Manipulating data: Sorting, merging, and appending, Introduction to SAS functions and macros, Conditional processing and subsetting data.

(15 Hours)

Module 3

Exploratory Data Analysis (EDA) and Statistical Analysis: Descriptive statistics: Mean, median, mode, variance, and standard deviation, Visualizing data using SAS procedures, Bivariate analysis: Correlation, scatter plots, and cross-tabulations, Introduction to statistical tests: T-tests, chi-square tests, and ANOVA. **(15 Hours)**

Module 4

Advanced SAS Programming and Modeling: Advanced data manipulation techniques: Arrays and SQL in SAS, Predictive modeling using linear regression and logistic regression, Model validation and evaluation techniques, Time series analysis and forecasting using SAS, Introduction to machine learning in SAS: Clustering and decision trees. **(15 Hours)**

Suggested Readings:

1. Ankerstjerne, A. (2019). ***SAS Programming for Data Science: A Beginner's Guide***. McGraw-Hill Education.
2. Cody, R. P., & Smith, J. K. (2018). ***Applied Statistics and the SAS Programming Language*** (6th ed.). SAS Institute.
3. Lora Delwiche, Susan J. Slaughter. (2019). ***The Little SAS Book: A Primer, Sixth Edition***. SAS Institute.

TEACHING LEARNING STRATEGIES

Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

MULTI DISCIPLINARY COURSES (MDC)

Semester I

MDC-1: MULTI DISCIPLINARY COURSE

KU1MDCSTA101- BASIC STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU1MDCSTA101	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an introduction to basic statistics, covering fundamental concepts and techniques used in statistical analysis. Divided into four modules, the course covers descriptive statistics, probability distributions, hypothesis testing, and inferential statistics. Through lectures, practical exercises, and real-world examples, students will gain a solid foundation in basic statistical methods and their applications.

COURSE OBJECTIVES:

- Descriptive Statistics: Introduce students to descriptive statistics for summarizing and visualizing data.

- Probability Distributions: Teach students about probability distributions and their properties, including the normal distribution.
- Hypothesis Testing: Enable students to understand the principles of hypothesis testing and perform basic tests of significance.
- Inferential Statistics: Introduce students to inferential statistics, including confidence intervals and simple linear regression.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand and apply descriptive statistics techniques to summarize and visualize data.
CO2	Demonstrate knowledge of probability distributions and their properties.
CO3	Perform basic hypothesis tests and interpret results.
CO4	Apply inferential statistics techniques such as confidence intervals and simple linear regression.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓		✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS:

Module 1:

Measures of central tendency (mean, median, mode), Measures of dispersion (range, variance, standard deviation), Data visualization techniques (histograms, box plots)
(15 Hours)

Module 2:

Introduction to probability theory, Discrete and continuous probability distributions, Properties of the normal distribution
(15 Hours)

Module 3:

Principles of hypothesis testing, One-sample and two-sample t-tests, Chi-square test for independence. **(15 Hours)**

Module 4:

Confidence intervals for means and proportions, Introduction to simple linear regression, Assumptions and limitations of statistical methods. **(15 Hours)**

Suggested Readings:

1. Moore, D. S., McCabe, G. P., & Craig, B. A. (2016). Introduction to the Practice of Statistics. W. H. Freeman.
2. Triola, M. F. (2017). Elementary Statistics. Pearson.
3. Frost, J. (2019). ***Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries.*** Jim Publishing.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

MDC-2: MULTI DISCIPLINARY COURSE

KU2MDCSTA201- CORRELATION AND REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	MDC	200	KU2MDCSTA201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on correlation and regression analysis, exploring the relationship between variables and predictive modeling techniques. Divided into four modules, the course covers correlation analysis, simple linear regression, multiple linear regression, and model evaluation techniques. Through lectures, practical exercises, and case studies, students will gain a comprehensive understanding of correlation and regression analysis and learn how to apply these techniques in real-world scenarios.

COURSE OBJECTIVES:

- Correlation Analysis: Introduce students to correlation analysis and teach them how to measure and interpret the strength and direction of relationships between variables.
- Simple Linear Regression: Teach students the principles of simple linear regression and how to build and interpret regression models with one predictor variable.
- Multiple Linear Regression: Enable students to understand multiple linear regression models and how to incorporate multiple predictor variables into regression analysis.
- Model Evaluation: Teach students techniques for evaluating regression models, including assessing model fit and identifying influential data points.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand and interpret correlation coefficients and their significance.
CO2	Build and interpret simple linear regression models with one predictor variable.
CO3	Construct and interpret multiple linear regression models with multiple predictor variables.
CO4	Evaluate the fit and performance of regression models and identify potential issues and limitations.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS:

Module 1

Introduction to correlation analysis, Pearson correlation coefficient, Spearman rank correlation coefficient, Interpreting correlation coefficients. **(15 Hours)**

Module 2

Principles of simple linear regression, Least squares estimation, Assessing model fit: coefficient of determination (R^2), Interpreting regression coefficients.
(15 Hours)

Module 3

Extending simple linear regression to multiple predictors, Multiple regression equation and interpretation, Assessing model fit: adjusted R^2, Dealing with multicollinearity.
(15 Hours)

Module 4

Residual analysis: assessing model assumptions, Influence and leverage diagnostics, Cross-validation techniques for model evaluation, Limitations and considerations in regression analysis. **(15 Hours)**

Suggested Readings:

1. Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2004). Applied Linear Statistical Models. McGraw-Hill Education.
2. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

MDC-3: MULTI DISCIPLINARY COURSE

KU3MDCSTA202- APPLIED STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	MDC	200	KU3MDCSTA202	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on applied statistical inference, exploring methods for making inferences and drawing conclusions from data. Divided into four modules, the course covers probability theory, sampling distributions, estimation, and hypothesis testing. Through lectures, practical exercises, and real-world applications, students will learn how to apply statistical inference techniques to solve problems and make informed decisions.

COURSE OBJECTIVES:

- Probability Theory: Introduce students to probability theory and its applications in statistical inference.
- Sampling Distributions: Teach students about sampling distributions and how they are used to make inferences about population parameters.
- Estimation: Enable students to understand and apply methods for estimating population parameters from sample data.
- Hypothesis Testing: Teach students how to formulate and test hypotheses using appropriate statistical tests and techniques.

COURSE OUTCOMES:

After successful completion of this course, students will be able to:

SL #	Course Outcomes
CO1	Understand and apply probability theory concepts in statistical inference.
CO2	Interpret sampling distributions and their role in making inferences about population parameters.
CO3	Use estimation techniques to estimate population parameters from sample data.
CO4	Formulate hypotheses, perform hypothesis tests, and draw conclusions based on statistical evidence.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS:

Module 1

Basics of probability: events, sample spaces, and probabilities, Conditional probability and independence, Bayes' theorem and its applications. **(15 Hours)**

Module 2

Introduction to sampling distributions, Sampling distributions of sample mean and sample proportion, Central limit theorem and its implications. **(15 Hours)**

Module 3

Point estimation: methods for estimating population parameters, Interval estimation: confidence intervals for population parameters, Margin of error and sample size determination. **(15 Hours)**

Module 4

Formulating null and alternative hypotheses, Types of errors in hypothesis testing: Type I and Type II errors, Common hypothesis tests: z-tests, t-tests, chi-square tests, Interpreting test statistics and p-values. **(15 Hours)**

Suggested Readings:

1. Casella, G., & Berger, R. L. (2002). ***Statistical Inference (2nd ed.).*** Duxbury Press.
2. Moore, D. S., McCabe, G. P., & Craig, B. A. (2016). ***Introduction to the Practice of Statistics***. W. H. Freeman.
3. Frost, J. (2020). ***Hypothesis Testing: An Intuitive Guide for Making Data Driven Decisions.*** Jim Publishers, USA.

TEACHING LEARNING STRATEGIES

· Hands on training, Lecturing, Visualization, Team Learning.

MODE OF TRANSACTION

· Lab session, Lecture, Seminar, Discussion, Questioning and Answering

ASSESSMENT RUBRICS:

Refer to section 5 of FYIMP- Computational Science - Scheme and Syllabus for the 3 credit courses with 2 Credit Theory + 1 Credit Practical.

MATHEMATICS
COURSE DETAILS

MATHEMATICS
COURSE DETAILS

Semester I

KU1DSCMAT101 LOGIC AND SET THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	CORE	100	KU1DSCMAT 101	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The objective is to lay a solid foundation in discrete mathematics, which is crucial for understanding more advanced topics in computer science, mathematics, and other fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding propositional logic, including the ability to construct truth tables, identify logical equivalences, and apply rules of inference to derive valid conclusions from logical statements
CO2	Students will be able to effectively use predicates and quantifiers to express mathematical statements and translate them into logical forms. They will apply nested quantifiers to formulate complex logical statements and reason about their truth values
CO3	Students will develop competence in set theory, including operations on sets (union, intersection, complement) and the ability to represent set relationships using Venn diagrams. They will solve problems involving set identities and apply set theory concepts to real-world scenarios.
CO4	Students will master the concepts of sequences and sums, including arithmetic and geometric sequences, series, and summation notation. They will apply mathematical induction to prove statements involving sequences and use induction to establish the validity of mathematical propositions

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Propositional logic, propositional equivalence, predicates and quantifiers, (Sections 1.1, 1.2,1.3, of the Text Book)

Module 2: Nested quantifiers, rules for inference, sets (Sections 1.4,1.5.2.1, of the Text Book)

Module 3: Set operators, functions (Sections 2.2, 2.3, of the Text Book)

Module 4: Sequences and sums, mathematical induction **(**Sections 2.4, 4.1of the Text Book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: Discrete Mathematics and Its Applications. by Kenneth H. Rosen, 6th edition, McGraw Hill.

Reference Books:

1. Susanna S Epp: Discrete Mathematics with Applications(4/e) Brooks/Cole Cengage Learning (2011) ISBN: 978-0-495-39132-6
2. Kenneth H. Rosen: Discrete Mathematics and Its Applications(7/e) McGraw-Hill, NY (2007) ISBN: 978-0-07-338309-5
3. OScar Levin, Discrete Mathematics: An Open Introduction, 3rd edition.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks

Seminar/Viva	20 Marks
Total	50 Marks

Semester II

KU2DSCMAT101: INTRODUCTION TO MATRIX THEORY, PARAMETRIC EQUATIONS AND POLAR CO -ORDINATES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU2DSCMAT 101	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The objective is to provide students with a solid understanding of the fundamental concepts of matrix theory, which are essential in various areas of mathematics, engineering, and applied sciences.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in fundamental concepts of matrices and matrix algebra, including operations such as addition, multiplication, and transposition. They will be able to solve systems of linear equations using matrix methods and apply matrix algebra to represent and solve practical problems.
CO2	Students will acquire the ability to compute determinants of square matrices and understand their geometric and algebraic interpretations. They will develop skills in finding the inverse of square matrices and apply these concepts to analyze the properties and behavior of linear transformations.
CO3	Students will gain knowledge of special types of matrices, such as symmetric, skew-symmetric, orthogonal, and diagonal matrices. They will explore applications of matrices in diverse fields, including computer science and statistics
CO4	Students will demonstrate proficiency in parametrizing plane curves, including the ability to represent curves using parametric equations and analyze their geometric properties. They will apply calculus techniques to parametric curves, such as finding derivatives and integrals, and interpret these results in the context of motion and geometry

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓		

COURSE CONTENTS

Module 1: Matrices and Matrix algebra, Systems of linear equations, The inverse of a square matrix and Determinants (Sections 1.1, 1.2, 1.3 and 1.4 of the Text Book 1).

Module 2: Some special types of matrices, more on system of linear equations, some places where matrices are found and Appendix (Sections 1.5,1.6.1.7 and 1.8, of the Text Book 1).

Module 3 Parametrizations of Plane Curves, Calculus with Parametric Curves, Polar Coordinates and Graphing Polar Coordinate Equations (Sections 11.1, 11.2, 11.3 and 11.4of the Text Book 2).

Module 4: Areas and Lengths in Polar Coordinates, Conic Sections and Conics in Polar Coordinates (Sections 11.5, 11.6 and 11.7 of the Text Book 2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Books:

1. David W Lewis, Matrix Theory, world scientific.
2. Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.

Reference Books:

1. Calculus early transcendentals sixth edition James Stewart McMaster University.
2. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU2DSCMAT102 CALCULUS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU2DSCMAT 102	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The mathematics required for viewing and analyzing the physical world around us is contained in calculus. The objective of the course is to introduce students to the fundamental ideas of limit, continuity and differentiability and also to some basic theorems of differential calculus. It is also shown how these ideas can be applied in the problem of sketching of curves and in the solution of some optimization problems of interest in real life.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would develop a solid understanding of what functions are and how they operate. They would learn about function notation, domain and range, and basic operations on functions such as addition, subtraction, multiplication, and division.
CO2	Students would become proficient in graphing functions and analyzing their behavior. This includes identifying key features such as intercepts, asymptotes, symmetry, and end behavior. Graphical analysis is crucial for visualizing functions and understanding their properties
CO3	Limits would be introduced as a foundational concept in calculus. Students would learn how to calculate limits algebraically, graphically, and numerically
CO4	Provide students with a strong foundation in pre-calculus concepts essential for success in calculus and other advanced mathematical disciplines.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Functions and Their Graphs, Combining Functions; Shifting and Scaling Graphs, Trigonometric Functions (Sections 1.1 to 1.3 of the text book)

Module 2: Graphing with Software, Exponential Functions, Inverse Functions and Logarithms (Sections 1.4 to 1.6 of the text book)

Module 3: Rates of Change and Tangents to Curves, Limit of a Function and Limit Laws, The Precise Definition of a Limit, One-Sided Limits (Sections 2.1 to 2.4 of the text book)

Module 4: Continuity, Limits Involving Infinity; Asymptotes of Graphs, Tangents and the Derivative at a Point, The Derivative as a Function (Sections 2.5 to 3.2 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>**Text Book**</u>: Thomas' Calculus Early Transcendentals (Thirteenth Edition).

Reference Books:

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).
5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th Edition, (2010
6. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7
7. Calculus early Transcendentals sixth edition James Stewart McMaster university

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester III

KU3DSCMAT201 CALCULUS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCMAT201	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: To provide students with a solid understanding of fundamental calculus concepts and techniques, preparing them for more advanced topics in calculus and their applications in science, engineering, and other disciplines.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Become proficient in finding derivatives using various techniques such as the power rule, product rule, quotient rule, chain rule, and implicit differentiation
CO2	Deepen their understanding of the derivative as a measure of instantaneous rate of change
CO3	Learn how to apply differentiation to solve problems in optimization, related rates, curve sketching, and motion
CO4	Teaching these sections would prepare students for more advanced topics in calculus, including techniques of integration, applications of integration, differential equations, and multivariable calculus

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick re-visit of 3.1 and 3.2, Differentiation Rules, The Derivative as a Rate of Change, Derivatives of Trigonometric Functions, The Chain Rule (Sections 3.3 to 3.6 of the text book)

Module 2: Implicit Differentiation, Derivatives of Inverse Functions and Logarithms, Inverse Trigonometric Functions, Extreme Values of Functions, (Sections 3.7,3.8,3.9 ,4.1 of the text book)

Module 3: The Mean Value Theorem, Monotonic Functions and the First Derivative Test, Concavity and Curve Sketching, Indeterminate Forms and L'Hôpital's Rule, Antiderivatives (Sections 4.2 to 4.5 and 4.8 of the text book)

Module 4: Area and Estimating with Finite Sums, Sigma Notation and Limits of Finite Sums, The Definite Integral, The Fundamental Theorem of Calculus (Sections 5.1,5.2.5.3 and 5.4 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book</u>: Thomas' Calculus Early Transcendentals (Thirteenth Edition)

<u>References:</u>

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).
5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th edition, (2010
6.Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7
7. Calculus early Transcendentals sixth edition James Stewart McMaster University

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU3DSCMAT202 DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCMAT202	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Is to provide students with a solid foundation in the theory and techniques of ordinary differential equations, preparing them to tackle more advanced topics in differential equations and their applications in science, engineering, and other fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Learn what an ODE is, what it means by its solution
CO2	Learn how to classify DEs, what it means by an IVP and so on
CO3	Learn to solve DEs that are in linear, separable and in exact forms
CO4	Learn to analyze the solution

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

Module1: Some Basic Mathematical Models; Direction Fields, Solutions of Some Differential Equations, Classification of Differential Equations, Linear Equations; Method of Integrating Factors, Separable Equations, Modeling with First Order Equations, (Sections 1.1 to1.3 and 2.1, 2.2 ,2.3, of text book)

Module 2: Differences Between Linear and Nonlinear Equations, Exact Equations and Integrating Factors, The Existence and Uniqueness Theorem (proof omitted), (Sections 2.4, 2.6, 2.8 of text book)

Module 3: Homogeneous Equations with Constant Coefficients, Solutions of Linear Homogeneous Equations: The Wronskian, Complex Roots of the Characteristic Equation, Repeated Roots; Reduction of Order, Nonhomogeneous Equations; Method of Undetermined Coefficients, Variation of Parameters, (Sections 3.1, 3.2,3.3, 3.4, 3.5, 3.6 of text book)

Module 4 Definition of the Laplace Transform, Solution of Initial Value Problems, Step Functions, Fourier series, The Fourier convergence theorem, Even and odd functions (Sections 6.1,6.2 and 6.3, 10.2, 10.3, 10.4 of Text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Elementary Differential Equations and Boundary Value Problems (Ninth Edition) -William E. Boyce and Richard C. DiPrima -John Wiley & Sons, Inc.

Reference Books:

1. Dennis G Zill &Michael R Cullen: Differential Equations with Boundary Value Problems(7/e): Brooks /Cole Cengage Learning (2009) ISBN: 0-495-10836-7.
2. R Kent Nagle, Edward B. Saff & Arthur David Snider: Fundamentals of Differential Equations(8/e) Addison-Wesley (2012) ISBN: 0-321-74773-9.
3. C. Henry Edwards &David E. Penney: Elementary Differential Equations (6/e) Pearson Education, Inc. New Jersey (2008) ISBN 0-13-239730-7
4. John Polking, Albert Boggess & David Arnold: Differential Equations with Boundary Value Problems(2/e) Pearson Education, Inc New Jersey (2006) ISBN 0-13-186236-7.
5. Henry J. Ricardo: A Modern Introduction to Differential Equations(2/e) Elsevier Academic Press (2009) ISBN: 978-0-12-374746-4.
6. James C Robinson: An Introduction to Ordinary Differential Equations Cambridge University Press (2004) ISBN: 0-521-53391-0.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU3DSCMAT203 NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCMAT203	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The aim of the course is to give an introduction to basic concepts of elementary number theory with minimal prerequisites. It starts from the very elementary topic such as integers, its factorization, congruence relations and basic but fundamental theorems of number theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Basic theory of integers, divisibility of integers, prime numbers and unique factorization of integers into prime numbers which are fundamental for various concepts from advanced algebras
CO2	Understand the concepts of linear Diophantine equations and congruence relations between integers which serves as an equivalence relation in the algebra structure of integers
CO3	Students would learn a specific class of congruences known as linear congruences and basic but fundamental theorems such as Fermat and Wilson Theorems
CO4	The students will understand some number theoretic functions such as divisor function, Euler's function which counts the number of divisors of an integer and some properties of divisors.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		
CO4	✓	✓	✓		

COURSE CONTENTS

Module 1: Integers, Contents Unique Factorization (Sections 1, 2 of the text book).

Module 2: Linear Diophantine Equations, Congruences (Sections 3,4 of the text book).

Module 3: Linear Congruences, Fermat's and Wilson's Theorems (Sections 5,6 of the text book).

Module 4: The Divisors of an Integer, Perfect Numbers, Euler's Theorem and Function (Sections 7,8 and 9 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Elementary Number Theory (Second edition) – Underwood Dudley - W. H. Freeman and company, New York

References:

1. David M Burton, Elementary Number theory, 7th edition, Mc Graw Hill.
2. T.M. Apostol, Introduction to Analytic Number Theory, Springer.
3. N. Koblitz, A Course in Number theory and Cryptography (2nd edition), Springer.
4. George E Andrews: Number Theory, Dover Publications (1971).
5. Andre Weil - Basic Number Theory (3rd edn.) Springer-Verlag (1974)
6. Grosswald, E. - Introduction to Number Theory Brikhauser (2nd edition) 1984.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU3DSCMAT204 NUMERICAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU3DSCMAT204	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of numerical analysis is to provide techniques and algorithms to find approximate numerical solution to problems in several areas of mathematics where it is impossible or hard to findthe actual/closed form solution by analytical methods and also to make an error analysis to ascertain the accuracy of the approximate solution

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand several methods such as bisection method, fixed point iteration method, regula falsi method etc. to find out the approximate numerical solutions of algebraic and transcendental equations with desired accuracy
CO2	Understand the concept of interpolation and also learn some well-known interpolation techniques
CO3	Understand a few techniques for numerical differentiation and integration and also realize their merits and demerits
CO4	Find out numerical approximations to solutions of initial value problems and also to understand the efficiency of various methods.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓		✓		✓
CO2	✓		✓		✓
CO3	✓		✓		✓
CO4	✓		✓		✓

COURSE CONTENTS

Module 1: The Bisection Method, Fixed-Point Iteration, Newton's Method and Its Extensions- Newton's Method (Newton- Raphson method), Convergence using Newton's Method, The Secant Method, The Method of False Position, : Error Analysis for Iterative Methods- Order of Convergence, linear and quadratic convergence, Multiple Roots, Modified Newton's method for faster convergence [Algoritham omitted] (Sections 2.1 to 2.4 of the Text book).

Module 2: Interpolation and the Lagrange Polynomial- motivation, Lagrange Interpolating Polynomials, error bound, Data Approximation and Neville's Method- motivation, Neville's Method,recursive method to generate Lagrange polynomial approximations, Divided Differences- k^{th} divided difference, Newton's divided difference formula, Forward Differences, Newton Forward-Difference Formula, Backward Differences, Newton Backward–Difference Formula, Centered Differences, Stirling's formula [Algoritham omitted] (Sections 3.1 to 3.3 of the Text book).

Module 3: Numerical Differentiation- approximation of first derivative by forward difference formula, backward difference formula, Three-Point Formulas, Three- Point Endpoint Formula, Three-Point Midpoint Formula [Five-Point Formulas, Five-Point Endpoint Formula, Five-Point Midpoint Formula omitted] Second Derivative Midpoint Formula to approximate second derivative, Round-Off Error Instability. Elements of

Numerical Integration-numerical quadrature, The Trapezoidal Rule, Simpson's Rule, Measuring Precision, Closed Newton- Cotes Formulas, Simpson's Three-Eighths rule, Open Newton-Cotes Formulas. Composite Numerical Integration-composite Simpson's rule, composite trapezoidal rule, composite midpoint rule, round off error stability (Sections 4.1, 4.3 and 4.4 of the Text book).

Module 4: Gaussian Quadrature-motivation, Legendre Polynomial, Gaussian Quadrature on Arbitrary Intervals [Algoritham omitted], The Elementary Theory of Initial-Value Problems, Euler's Method- derivation using Taylor formula, Error bounds for Euler Method. Higher-Order Taylor Methods- local truncation error, Taylor method of order n and order of local truncation error, Runge-Kutta Methods- only Mid-Point Method, Modified Euler's Method and Runge-Kutta Method of Order Four are required. [derivation of formula omitted in each case] (Sections 4.7, 5.1 to 5.4 of the Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Numerical Analysis (10/e): Richard L. Burden, J Douglas Faires, Annette M. Burden Brooks/Cole Cengage Learning (2016) ISBN:978-1-305-25366-7.

Reference Books:

1. Kendall E. Atkinson, Weimin Han: Elementary Numerical Analysis(3/e) John Wiley & Sons (2004) ISBN:0-471-43337-3[Indian Edition by Wiley India ISBN:978-81-265-0802-0].
2. James F. Epperson: An Introduction to Numerical Methods and Analysis(2/e) John Wiley & Sons (2013) ISBN: 978-1-118-36759-9.
3. S S Sastri: Introductory Methods of Numerical Analysis(5/e) PHILearning Pvt. Ltd. (2012) ISBN:978-81-203-4592-8.
4. Timothy Sauer: Numerical Analysis(2/e) Pearson (2012) ISBN: 0-321-78367-0.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IV

KU4DSCMAT201 CALCULUS III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCMAT201	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective is to introduce students to more advanced integration techniques beyond the basic methods covered earlier

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would develop a deeper understanding of integration techniques such as integration by parts, trigonometric substitution, partial fractions, and integration involving trigonometric, exponential, and logarithmic functions
CO2	Will get a thorough knowledge about sequences and series also about their convergence
CO3	Teaching these sections would help students enhance their problem-solving skills by providing them with opportunities to apply advanced integration techniques to solve complex problems in various contexts, including physics, engineering, economics, and other fields.
CO4	Would equip students with advanced calculus knowledge and skills, preparing them for further study in mathematics, science, engineering, and other fields, as well as for careers that require strong analytical and problem-solving abilities

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Volumes Using Cross-Sections, Volumes Using Cylindrical Shells, Arc Length, Areas of Surfaces of Revolution (Sections ,6.1, 6.2,6.3 and 6.4 of the text book).

Module 2: The Logarithm Defined as an Integral, Hyperbolic Functions, Using Basic Integration Formulas, Integration by Parts (Sections 7.1,7.3,8.1 and 8.2 of the text book).

Module 3: Trigonometric Integrals**,** Trigonometric Substitutions, Integration of Rational Functions by Partial Fractions, Improper Integrals (Sections 8.3,8.4,8.5, and 8.8 of the text book).

Module 4: Sequences, Infinite Series**,** Convergence of series; the integral test, comparison test, absolute convergence (Sections 10.1,10.2 ,10.3,10.4 and 10.5, of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas' Calculus Early Transcendentals (Thirteenth Edition).

Reference Books:

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).
5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th edition, (2010
6. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7
7. Calculus early Transcendentals sixth edition James Stewart McMaster University

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU4DSCMAT202 INTRODUCTION TO GRAPH THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCMAT202	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Is to provide strong basic foundation in Graph Theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would gain a solid understanding of the fundamental concepts of graph theory, including definitions of graphs, vertices, edges, and the basic properties of graphs.
CO2	Students would learn different ways to represent graphs, including adjacency matrices, incidence matrices, and graph drawings. They would understand the advantages and limitations of each representation method
CO3	Students would become familiar with basic graph properties such as degree, degree sequences, and walks in graphs. They would learn to identify special types of graphs such as complete graphs, cycles, trees, and bipartite graphs.
CO4	Students would learn about graph connectivity, including connected graphs, components, and cut vertices/edges. They would study paths, cycles, and Eulerian and Hamiltonian paths in graphs

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1 - An Introduction to Graphs**;** The Definition of a graph, Graphs as models, more definitions, Vertex Degrees, Sub graphs (Theorems omitted). (Sections 1.1, 1.2, 1.3, 1.4, 1.5of the Text).

Module 2 - Trees and connectivity matrix representation of graphs; Paths and Cycles, Definition of trees and simple properties, Bridges, (Sections 1.6, ,1.7, 2.1, 2.2 of the Text).

Module 3- Euler Tour and Hamiltonian cycles; Spanning trees, Cut vertices and connectivity**.** Euler tours (Excluding Fleury's algorithm) (Sections 2.3,2.6, 3.1, of the Text).

Module 4 - The Chinese Postman Problem, Hamiltonian Graphs, The Travelling salesman Problem (Algorithm Omitted), Plane and planar Graphs. (Sections 2, 3.2, 3.3, 3.4,5.1 of the Text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: J. Clark and D.A. Holton, A First Look at Graph Theory, Allied Publishers.

Reference Books:

1. R. Balakrishnan and K. Ranganathan, A Text Book of Graph Theory (2^{nd} edition), Springer.
2. J.A. Bondy and U.S.R. Murthy, Graph Theory with Applications, Macmillan.
3. F. Harary, Graph Theory, Narosa.
4. K.R. Parthasarathy, Basic Graph Theory, Tata-McGraw Hill.
5. G. Chartrand and P. Zhang, Introduction to Graph Theory, Tata McGraw Hill.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU4DSCMAT203 LINEAR ALGEBRA I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCMAT203	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Students will able to apply concepts from calculus and linear algebra to solve problems involving geometric objects in three-dimensional space. They will interpret and analyze relationships between vectors, lines, planes, and surfaces, demonstrating the connection between calculus and linear algebra in spatial contexts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Demonstrate proficiency in three-dimensional coordinate systems and vectors, including representing points and vectors in space, computing distances and magnitudes, and applying the dot product to calculate angles and projections.
CO2	Develop skills in using the cross product to compute vector products and geometric applications
CO3	Acquire knowledge of vector spaces and subspaces, including understanding concepts of null spaces and column spaces associated with matrices. They will analyze linear transformations and their properties, including injectivity, subjectivity, and linearity
CO4	Demonstrate proficiency in identifying and working with linearly independent sets and bases of vector spaces. They will be able to determine coordinate systems and represent vectors as linear combinations of basis vectors.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Three-Dimensional Coordinate Systems, Vectors and The Dot Product (Sections 12.1, 12.2, 12.3 of the Text book 1).

Module 2: The Cross Product, Lines and Planes in Space and Cylinders and Quadric Surfaces (Sections 12.4, 12.5, 12.6 of the text book 1).

Module 3: Vector Spaces and Subspaces Null Spaces, Column Spaces, and Linear Transformations (Sections 4.1 and 4.2 of the Text Book 2).

Module 4: Linearly Independent Sets; Bases and Coordinate Systems (Sections 4.3 and 4.4 of the text book 2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Books:

1. Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.
2. Linear Algebra and its Applications, David C Lay, Stephen R Lay and Judi J. McDonald, 5th edition, Publisher: Pearson.

Reference Books:

1. Serge A Lang: Linear Algebra; Springer.
2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.
3. Thomas W. Hungerford: Algebra; Springer 1980.
4. S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition.
5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.
6. S. Axler Linear Algebra Done right, Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU4DSCMAT204 VECTOR VALUED FUNCTIONS AND MULTIVARIABLE CALCULUS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU4DSCMAT204	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Studying this course provide students with a solid foundation in multivariable calculus, preparing them for further studies in mathematics, physics, engineering, and other fields where multivariable calculus is applied.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students should be able to define and work with vector functions, understanding their representation and properties.
CO2	Students should be able to compute derivatives and integrals of vector-valued functions, including finding tangent vectors, normal vectors, and curvature.
CO3	Students should understand the concept of tangent planes to surfaces and how to compute them.
CO4	Students should be able to compute double and triple integrals over rectangular and non-rectangular regions.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Curves in Space and Their Tangents, Integrals of Vector Functions; Projectile Motion, Arc Length in Space, Curvature and Normal Vectors of a Curve (Sections 13.1 to 13.4 of the Text Book)

Module 2: Tangential and Normal Components of Acceleration, Velocity and Acceleration in Polar Coordinates, Functions of Several Variables, Limits and Continuity in Higher Dimensions (Sections 13.5 to 14.2 of the Text Book)

Module 3: Partial Derivatives, The Chain Rule, Directional Derivatives and Gradient Vectors, Tangent Planes and Differentials (Sections 14.3 to 14.6 of the Text Book)

Module 4: Extreme Values and Saddle Point, Double and Iterated Integrals over Rectangles, Double Integrals over General Regions, Area by Double Integration (Sections14.7, 15.1 to 15.3 of the Text Book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education

Reference Books:

1. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7.
2. Calculus early Transcendentals sixth edition James Stewart McMaster University.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

KU5DSCMAT301ALGEBRA I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course starts with the structure of binary structure on a set. The aim of the course is to introduce the very basics of group theory starting from sets and binary operations. We focus more on exercise solving from each section.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The student should able to be familiar with binary structures on a set
CO2	The student should able to be familiar with the notions of groups, subgroups, cyclic groups.
CO3	The student should able to be familiar with Symmetric group and its structure
CO4	The student should able to be familiar with the direct product of groups and the classification of finitely generated abelian groups.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sets and Relations, Introduction and Examples, Binary Operations, Isomorphic Binary Structures (Sections 0,1,2,3).

Module 2: Groups, Subgroups, Cyclic Groups, Generating Sets and Cayley Digraphs (Sections 4, 5, 6 and 7).

Module 3: Groups of Permutations, Orbits, Cycles and the Alternating Groups, Cosets and the Theorem of Lagrange (Sections 8, 9, and 10).

Module 4: Direct Products and Finitely Generated Abelian Groups (Section 11).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>**Text Book**</u>: J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003)

Reference Books:
1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.
2. I.N. Herstein – Topics in Algebra- Wiley Eastern.
3. J.A.Gallian – Contemporary Abstract Algebra.
4. Hoffman & Kunze – Linear Algebra – Prentice Hall.
5. M. Artin, Algebra, Prentice Hall, 1991.

TEACHING LEARNING STRATEGIES
- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION
- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU5DSCMAT302 COMPLEX ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The goal of this course is to give an introduction to the field of complex numbers, its representation in the plane, basic algebraic and topological properties, functions of one complex variable, analyticity of complex functions, and properties of some particular complex functions.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand field of complex numbers, its representation in the plane, basic algebraic and topological properties
CO2	Understand functions of one complex variable, limit of complex functions and basic limit theorems.
CO3	Students would learn differentiability of complex functions, Cauchy Riemann Equations and the sufficient conditions for differentiability.
CO4	The students will understand the important concept of analyticity of complex functions, examples, Harmonic functions and its connection with analyticity and some class of complex functions and some identities involving them.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sums and products, Basic Algebraic Properties, Further Properties, Vectors and Moduli, Complex conjugates, Exponential Form, Products and Power in Exponential Form, Argument of Products and Quotients, Roots of Complex Numbers, Examples, Regions in the Complex plane. (Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 of the text book).

Module 2: Functions of Complex Variable, Mappings, Mappings by the Exponential Function, Limits, Theorems of Limits, Limits Involving the Point at Infinity. (Sections 12, 13, 14, 15, 16 and 17 of the Text book).

Module 3: Continuity, Derivatives and Differentiation Formulas. Cauchy-Riemann Equations, Sufficient Conditions for Differentiability, Polar Coordinates. (Sections 18, 19, 20, 21, 22 and 23 of the text book).

Module 4: Analytic Functions, Examples and Harmonic Functions. The Exponential Function, The Logarithmic Function, Some Identities Involving Logarithms, Complex Exponents, Trigonometric Functions Hyperbolic Functions Inverse Trigonometric and Hyperbolic functions. (Sections 24, 25, 26, 29, 30, 32, 33, 34 and 35 of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mc Graw -Hill, (2009).

Reference Books:

1.Conway J.B. – Functions of One Complex Variable I – Second edition, Springer international student edition.
2. J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), McGraw-Hill, (2009).
3. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987.
4. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford.
5. S Lang - Complex Analysis, Fourth Edition, Graduate texts in Mathematics 103, Springer, Second Indian Reprint 2013.
6. Herb Silverman - Complex Variables, Houghton Mifflin Co., 1975.
7. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007.
8. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU5DSCMAT303 LINEAR ALGEBRA II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course would be to equip students with the mathematical tools and concepts necessary for further study in linear algebra, as well as applications in various fields such as engineering, physics, computer science, and economics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding the concept of dimension of a vector space, including determining the dimension of subspaces and applying the rank-nullity theorem. They will be able to compute the rank of matrices and relate it to the solutions of linear systems
CO2	Students will develop skills in performing change of basis in vector spaces, including finding transition matrices between different bases and representing vectors in new coordinate systems. They will apply change of basic techniques to solve problems involving linear transformations
CO3	Students will acquire knowledge of eigenvectors and eigenvalues of matrices, including computing eigenvalues and corresponding eigenvectors. They will apply eigenvalue-eigenvector theory to diagonalize matrices and solve systems of linear differential equations
CO4	Students will demonstrate the ability to find characteristic equations of matrices and use them to compute eigenvalues. They will apply the concept of diagonalization to transform matrices into diagonal form using eigenvectors and eigenvalues.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The Dimension of a Vector Space and Rank (Sections 4.5 and 4.6 of the text book) .

Module 2: Change of Basis and supplementary exercises (Section 4.7 of the text book).

Module 3: Eigenvectors and Eigenvalues and The Characteristic Equation (Sections 5.1 and 5.2 of the text book).

Module 4: Diagonalization, Eigen vectors and Linear Transformations (Section 5.3 and 5.4 of the text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Linear Algebra and its Applications, David C Lay, Stephen R Lay and Judi J. McDonald, 5th edition, Publisher: Pearson

Reference Books:

1. Serge A Lang: Linear Algebra; Springer.
2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.
3. Thomas W. Hungerford: Algebra; Springer 1980.
4. S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition.
5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.
6. S. Axler Linear Algebra Done right, Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU5DSCMAT304 REAL ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU5DSCMAT304	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The primary goal is for students to develop a deep understanding of the fundamental concepts of real analysis. This includes concepts such as sequences, series, limits, and convergence.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The students will understand the construction of real numbers, properties of order, and algebraic properties. Additionally, students would learn about sets, set operations, and basic set theory.
CO2	Students would learn about sequences of real numbers, including convergence, divergence, and limits of sequences
CO3	The students will understand the concept of a limit of a sequence and to be able to determine convergence or divergence using various convergence tests
CO4	Throughout these sections, the objective is to develop students' skills in reading and writing mathematical proofs

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sets and Functions, Mathematical Induction, Finite and Infinite Sets, The Algebraic and Order Properties of R. (Sections 1.1, 1.2, 1.3, 2.1, of Text book 1).

Module 2: Absolute Value and Real Line, The completeness Property of R, Applications of the Supremum Property, Intervals (Sections 2.2,2.3 2.4, 2.5, of Text book).

Module 3: Sequences and Their Limits, Limit Theorems, Monotone Sequences, Subsequences and the Bolzano-Weierstrass Theorem, (Sections 3.1, 3.2, 3.3, 3.4, of Text book).

Module 4: The Cauchy Criterion, Properly Divergent Sequences, Introduction to Series, (Sections 3.5, 3.6 3.7, of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: R.G. Bartle and D.N. Sherbert, Introduction to Real Analysis, Third Edition, John Wiley & Sons (2000).

Reference books:

1. G.B Folland: A Guide to Advanced Real Analysis- Mathematical Association of America Publishing.

2. Elias M. Stein, Rami Shakarchi: REAL ANALYSIS Measure Theory, Integration, and Hilbert Spaces Princeton University press.
3. Kenneth A. Ross Elementary Analysis the Theory of Calculus Springer-Verlag, New York, 2013.
4. Andrew M. Bruckner, Judith B. Bruckner, Brian S. Thomson Real analysis Prentice-Hall, 2001.
5. Sterling K. Berberian Fundamentals of Real Analysis Springer-Verlag, New York 1999.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Electives for 5th Semester

KU5DSEMAT301 INTRODUCTION TO GEOMETRY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU5DSEMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main objective of this course is ideally be that students gain a solid understanding of basic geometric concepts, develop skills in logical reasoning and geometric proofs, and are able to apply these concepts to solve problems in geometry.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students should be able to define and identify basic geometric terms such as points, lines, planes, angles, and geometric figures.
CO2	Students should be able to identify and apply the properties of lines, angles, and their relationships, including parallel lines and transversals, angle properties, and theorems related to intersecting lines.
CO3	Students should develop skills in logical reasoning and geometric proofs. They should be able to apply deductive reasoning to prove geometric theorems and solve geometric problems.
CO4	Students should be able to apply geometric concepts and principles to solve problems in various contexts, including real-world applications and mathematical puzzles.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1		✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3		✓	✓	✓	✓
CO4		✓	✓	✓	✓

COURSE CONTENTS

Module 1: Conic Sections, Focus-Directrix Definition of the Non-Degenerate Conics, Focal Distance Properties of Ellipse and Hyperbola, Properties of Conics, Properties of Conics (Sections 1.1.1,1.1.3,1.1.4,1.2 and 1.3 of the Text Book).

Module 2: Geometry and Transformations - What is Euclidean Geometry? Affine Transformations and Parallel Projections- Affine Transformations, Properties of Affine Transformations, (Sections 2.1,2.2 and 2.3 of the Text Book).

Module 3: Using the Fundamental Theorem of Affine Geometry (sub section 2.4.4 omitted), Using the Fundamental Theorem of Affine Geometry, Perspective (Sections 2.4,2.5 and 3.1 of the Text Book).

Module 4: The Projective Plane $\mathbb{RP}^2$, Projective Transformations, Using the Fundamental Theorem of Projective Geometry (Sections 3.2, 3.3 and 3.4 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>**Text Book:**</u> Geometry(2/e): David A Brannan, Mathew F Espen, Jeremy J Gray Cambridge University Press (2012) ISBN: 978-1-107-64783-1

<u>**Reference Books:**</u>

1. George A Jennings: Modern Geometry with Applications University text, Springer (1994) ISBN:0-

387-94222-X
2. Walter Meyer: Geometry (2006) ISBN:0-12-369427-0 and its Application(2/e) Elsever, Academic Press
3. Judith N Cederberg: A Course in Modern Geometries(2/e) UTM,Springer (2001)ISBN: 978-1-4419-3193-1
4. Patric J Ryan: Euclidean and Non- E u c l i d e a n Geometry-An Analytic Approach Cambridge University Press, International Student Edition (2009) ISBN:978-0-521-12707-3
5. Michele Audin: Geometry University text, Springer (2003) ISBN:3-540-43498-4

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU5DSEMAT302 MULTIPLE INTEGRALS AND VECTOR INTEGRATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU5DSEMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course is to deepen students' understanding of calculus and its applications, equip them with advanced techniques for solving mathematical problems, and prepare them for further studies in mathematics, science, engineering, or related disciplines.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The goal is for students to become proficient in integrating a wide range of functions using different methods.
CO2	Students would learn how to identify and compute improper integrals and understand the convergence or divergence of such integrals
CO3	Students would learn how to represent curves using polar coordinates, find derivatives and integrals in polar coordinates, and understand the relationship between polar and Cartesian coordinates.
CO4	The objective would be for students to understand vector concepts and their applications in physics, engineering, and other fields.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Double Integrals in Polar Form, Triple Integrals in Rectangular Coordinates, Triple Integrals in Cylindrical and Spherical Coordinates**,** Substitutions in Multiple Integrals (Sections 15.4,15.5,15.7 and 15.8 of the Text Book).

Module 2: Line Integrals, Vector Fields and Line Integrals: Work, Circulation, and Flux, Path Independence, Conservative Fields, and Potential Functions (Sections 15.4,15.5,15.7 and 15.8 of the Text Book).

Module 3: Green's Theorem in the Plane, Surfaces and Area, Surface Integrals (Sections 16.4,16.5,15.7 and 16.6 of the Text Book).

Module 4: Stokes' Theorem, The Divergence Theorem and a Unified Theory (Sections 16.7 and 16.8of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thoms' Calculus Early Transcendentals (Thirteenth Edition).

References:

1. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7
2. Calculus early Transcendentals sixth edition James Stewart McMaster university

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU5DSEMAT303 THEORY OF EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU5DSEMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			6. Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course would be to provide students with a solid foundation in the theory and applications of equations, equip them with problem-solving skills, and prepare them for further studies in mathematics or related fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students might learn various methods for solving polynomial equations, including factoring, synthetic division, long division, and the use of the rational root theorem. The objective would be for students to become proficient in solving polynomial equations of different degrees.
CO2	Students might study equations in different contexts, including algebraic, geometric, and applied settings. The objective would be for students to understand how equations arise in various mathematical and real-world problems and how to formulate and solve them effectively.
CO3	Students might explore applications of equation theory in various fields, including physics, engineering, economics, and cryptography
CO4	The overarching objective might be to develop students' problem-solving skills by challenging them with a variety of equation-related problems and exercises.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Integral rational functions or polynomials., Multiplication of polynomials, Division of polynomials, The remainder theorem, Synthetic Division, Horner's process, Taylor formula, Highest common divisor of two polynomials (Sections II.1 to II.8 of the Text Book).

Module 2: Algebraic equations, Identity theorem, The Fundamental theorem of Algebra, Imaginary roots of equations with real coefficients, Relations between roots and coefficients, Discovery of multiple roots (Sections III.1 to III.6 of the Text Book).

Module 3: Limits of roots, Method to find upper limit of positive roots, Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted] Integral roots, Rational roots (Sections IV.1 to IV.5 of the Text Book).

Module 4: What is the solution of an equation? Cardan's formulas, Discussion of solution irreducible case, Trigonometric solution, Solutions of biquadratic equations, Ferrari method[example 2 omitted] (Sections V.1 to V.6 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Theory of Equations: J V Uspensky McGraw Hill Book Company, Inc. (1948) ISBN:07-066735-7

Reference Books:

1. Dickson L.E: Elementary Theory of Equations John Wiley and Sons,Inc.NY(1914).
2. Turnbull H.W: Theory of Equations(4/e) Oliver and Boyd Ltd Edinburg (1947).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

KU6DSCMAT301 ALGEBRA II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSCMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course gradually moves to the core of abstract algebra. The objective of the course is to introduce an important concept of factor group and computations of various factor groups. This course also aims at introducing the theory of rings and fields which are the fundamental base for Galois theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand normal subgroups of a groups and can compute various factor groups. They also understand the concept of simple groups.
CO2	Understand the most general algebraic structure with two binary operations namely rings. Rings with more structure like integral domain, Fields are also studied.
CO3	Study one important class of rings, polynomial rings and factorization of polynomials which are fundamental in the Galois theory
CO4	Understand homomorphisms on rings and the concepts of ideals and factor rings. Students are introduced on solving number theoretic problems using the techniques of ring theory.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Homorphisms, Factor Groups, Factor Group Computations and Simple Groups (Sections 13, 14 and 15 of the text book).

Module 2: Rings and Fields, Integral Domains, Fermat's and Euler's Theorems (Sections 18, 19 and 20 of the text book)

Module 3: Rings of Polynomials, Factorization of Polynomials over a Field (Sections 22 to 23 of the text book)

Module 4: Homomorphisms and Factor Rings, Prime and Maximal ideals (Sections 26 and 27 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003)

Reference Books:
1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.
2. I.N. Herstein – Topics in Algebra- Wiley Eastern
3. J.A.Gallian – Contemporary Abstract Algebra
4. Hoffman & Kunze – Linear Algebra – Prentice Hall
5. M. Artin, Algebra, Prentice Hall, 1991

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU6DSCMAT302 COMPLEX ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSCMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The one important goal of this course is to introduce the integration of complex valued functions across curves in the plane. Another important topic is the representation of analytic functions as power series.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The integration of complex valued functions across curves in the plane and establishes the Cauchy – Goursat theorem of existence of anti-derivatives of complex functions
CO2	Understands the Cauchy integral formula of behavior integration along closed curves in the plane. Bounds of analytic functions are discussed and as an application Fundamental theorem of algebra is also discussed.
CO3	Students would learn sequences and series of complex numbers and special types of series such as Taylor and Laurent series which are important in the theory of analytic functions
CO4	The students will understand the power series of representation of analytic functions on simply connected domains and discusses the loss of analyticity at certain points known as singular points and behavior of functions at these points.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Derivatives of Functions w(t), Definite Integrals of Functions w(t), Contours, Con- tour Integrals, Some Examples. Upper Bounds for Moduli of Contour Integrals, Antiderivatives and Cauchy Goursat Theorem. (Sections 33, 37, 38, 39, 40, 41 43, 44, and 46 of the text book).

Module 2: Cauchy Integral Formula, An Extension of the Cauchy Integral Formula, Liouville's Theorem and the Fundamental Theorem of Algebra, Maximum Modulus Principle. (Sections 50, 51, 53 and 54 of the text book).

Module 3: Convergence of Sequences, Convergence of Series, Taylor Series, Examples, Laurent Series, Examples. (Sections 55, 56, 57, 59, 60 and 62 of Text book).

Module 4: Absolute and Uniform Convergence of Power Series, Continuity of Sums of Power Series, Integration and Differentiation of Power Series, Uniqueness of Series Representations, Multiplication and Division of Power Series, Isolated Singular Points and Residues Cauchy's Residue Theorem, Residue at Infinity. (Sections:63, 64, 65, 66, 67, 68, 69 and 71, of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book : J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), McGraw-Hill,(2009).

References Books:

1. Conway J.B. – Functions of One Complex Variable I – Second edition, Springer international student edition.
1. J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mcgraw-Hill,(2009).
2. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987
3. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford
4. S Lang - Complex Analysis, Fourth Edition, Grauate texts in Mathematics 103, Springer, Second Indian Reprint 2013.
5. Herb Silverman - Complex Variabies,Houghton Mifflin Co., 1975.
6. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007
7. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU6DSCMAT303 REAL ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU6DSCMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives:

To provide students with a deeper understanding of limit and continuity of functions, and basic concepts of differentiation. These sections build upon the foundational concepts introduced earlier in the text and prepare students for more advanced topics in real analysis and related areas of mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Able to find limit of a function at a given point
CO2	Able to check the continuity of a real valued function at a given point
CO3	Able to find the limit of quotient of functions
CO4	Learn point wise and uniform convergence

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: A quick review of (Limits of Functions, Limits Theorems, Some Extensions of Limit Concept). Continuous Functions, Combinations of Continuous Functions. (sections 4.1,4.2, 4.3, 5.1, 5.2, of Text book).

Module 2: Continuous functions on Intervals, Uniform Continuity, Continuity and Gauges, Monotone and Inverse functions (Sections5.3, 5.4, 5.5 and 5.6 of Text book).

Module 3: The Derivative, The Mean Value Theorem, L'Hospital Rules and Taylors Theorem (Sections 6.1, 6.2, 6.3 and 6.4 of Text book).

Module 4: Pointwise and Uniform Convergence, Interchange of Limits, The Exponential and Logarithmic Functions and Trigonometric Functions. (Sections 8.1, 8.2, 8.3 and 8.4 of Text book).

Module X: The Reimann integral, Chapter 7 of the text book

Text Book: R.G. Bartle and D.N. Sherbert, Introduction to Real Analysis, Third Edition, John Wiley & Sons (2000).

Reference books:

1. G.B Folland: A Guide to Advanced Real Analysis Mathematical Association of America Publishing.

2. Elias M. Stein, Rami Shakarchi: REAL ANALYSIS Measure Theory, Integration, and Hilbert Spaces Princeton University press.

3. Kenneth A. Ross Elementary Analysis the Theory of Calculus Springer-Verlag, New York, 2013.

4. Andrew M. Bruckner, Judith B. Bruckner, Brian S. Thomson Real analysis Prentice-Hall, 2001.

5. Sterling K. Berberian Fundamentals of Real Analysis Springer-Verlag, New York 1999.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Electives for 6th Semester)

KU6DSEMAT301 LINEAR PROGRAMMING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSEMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course is to equip students with a solid understanding of optimization theory and its applications, as well as the analytical skills necessary to formulate and solve optimization problems in diverse contexts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to solve linear programming problems geometrically
CO2	Solve LP problems more effectively using Simplex algorithm *via*. the use of condensed tableau of A.W. Tucker
CO3	Understand duality theory, a theory that establishes relationships between linear programming problems of maximization and minimization
CO4	Solve transportation and assignment problems by algorithms that take advantage of the simpler nature of these problems

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓		✓	✓	
CO2	✓		✓	✓	
CO3	✓		✓	✓	
CO4	✓		✓	✓	

COURSE CONTENTS

Module 1 : Chapter1; Geometric Linear Programming: Profit Maximization and Cost Minimization, typical motivating examples, mathematical formulation, Canonical Forms for Linear Programming Problems, objective functions, constraint set, feasible solution, optimal solution , Polyhedral Convex Sets, convex set, extreme point, theorems asserting existence of optimal solutions, The Two Examples Revisited, graphical solutions to the problems, A Geometric Method for Linear Programming, the difficulty in the method, Concluding Remarks. Chapter2; The Simplex Algorithm:- Canonical Slack Forms for Linear Programming Problems; Tucker Tableaus, slack variables, Tucker tableaus, independent variables or non-basic variables, dependent variables or basic variables, .An Example: Profit Maximization, method of solving a typical canonical maximization problem. (Sections given in the Text book).

Module 2: The Pivot Transformation, The Pivot Transformation for Maximum and Minimum Tableaus, An Example: Cost Minimization, method of solving a typical canonical minimization problem, The Simplex Algorithm for Maximum Basic Feasible Tableaus, The Simplex Algorithm for Maximum Tableaus, Negative Transposition; The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anticycling Rules, Concluding Remarks. Chapter 3; Noncanonical Linear Programming Introduction, Unconstrained Variables, Equations of Constraint, Concluding Remarks (Sections given in the text book).

Module 3: Chapter 4; Duality Theory: - Duality in Canonical Tableaus, The Dual Simplex Algorithm, The Dual Simplex Algorithm for Minimum Tableaus, The Dual Simplex Algorithm for Maximum Tableaus, Matrix Formulation of Canonical Tableaus, The Duality Equation, The Duality Theorem, Concluding Remarks. (Sections given in the text book).

Module 4: Chapter 6; Transportation and Assignment Problems: - The Balanced Transportation Problem, The Vogel Advanced-Start Method (VAM), The Transportation Algorithm, Another Example, Unbalanced Transportation Problems, The Assignment Problem, The Hungarian Algorithm, Concluding Remarks, The Minimum-Entry Method, The Northwest-Corner Method (Sections given in the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Linear Programming and Its Applications: James K. Strayer Under-Graduate Texts in Mathematics Springer (1989) ISBN: 978-1-4612-6982-3.

Reference Books:

1. A. Ravindran, D.T. Philips and J.J. Solberg: Operations Research-Principles and Practices (2nd Edn.); John Wiley & Sons, 2000
2. G. Hadley: Linear Programming; Addison-Wesley Pub Co Reading, 1975.
3. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall of India, 2000.
4. H.S. Kasana and K.D. Kumar: Introductory Operations Research-Theory and Applications, Springer-Verlag, 2003.
5. James K. Strayer: Linear Programming and Its Applications,Under graduate Texts in Mathematics Springer (1989), Springer-Verlag, 2003.
6. R. Panneerselvam: Operations Research, PHI, New Delhi (Fifth printing), 2004
7. Robert J.Vanderbei: Linear Programming: Foundations and Extensions(2/e) Springer Science, Business Media LLC (2001) ISBN: 978-1-4757-5664-7
8. Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research(10/e) McGraw-Hill Education, 2 Penn Plaza, New York (2015) ISBN: 978-0-07-352345-3

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU6DSEMAT302 TOPOLOGY OF METRIC SPACES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSEMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching these chapters would be to equip students with a solid understanding of fundamental concepts in metric spaces and their applications, preparing them for more advanced studies in mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would learn about metric spaces, basic definitions, and examples.
CO2	Students would learn the definitions and properties of open and closed sets in metric spaces. Students might learn about the relationships between these sets, as well as basic properties and examples.
CO3	Would learn the concept of topological spaces, which are generalizations of metric spaces where the notion of distance is replaced by a notion of closeness. Students might study basic definitions, topological properties, and examples of topological spaces
CO4	Would be to equip students with a solid understanding of fundamental concepts in metric spaces and their applications, preparing them for more advanced studies in Mathematics.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Metric Spaces, Metric Subspaces and Metric Superspaces, Isometries, Metrics on Products,: Metrics and Norms on Linear Spaces-[example1.7.8 omitted], Distances from Points to Sets , Inequalities for Distances, Distances to Unions and Intersections 2.5: Isolated Points, Accumulation Points, Distances from Sets to Sets (Sections from Chapters1 and 2 of the Text book).

Module 2: Boundary Points, Sets with Empty Boundary, Boundary Inclusion, Closure and Interior, Inclusion of Closures and Interiors, Open and Closed Subsets, Dense Subsets, Topologies Topologies on Subspaces and Super spaces, Topologies on Product Spaces (Sections from Chapters 3 and 4 of the Text book).

Module 3: Open and Closed Balls, Using Balls, Definition of Convergence for Sequences, Limits, Convergence in Subspaces and Super spaces, Convergence Criteria for Interior and Closure, Convergence of Subsequences, Cauchy Sequences (Sections from Chapters5 and 6 of Text book).

Module 4: Bounded Sets, Spaces of Bounded Functions, Convergence and Boundedness, Uniform and Pointwise Convergence, Local Continuity, Global Continuity, Continuity of Compositions, Connected Metric Spaces, Connected Subsets, Connectedness and Continuity (Sections from Chapters7,8 and 11 of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: **Metric Spaces:** Mícheál Ó Searcóid Undergraduate Mathematics Series Springer-Verlag London Limited (2007) ISBN: 1-84628-369-8

Reference books:

1. S. Kumaresan, Topology of Metric Spaces, Alpha Science International Ltd, 2005.
2. Irving Kaplansky: Set Theory and Metric Spaces Allyn and Bacon,Inc. Boston(1972).
3. E.T.Copson: Metric Spaces Cambridge University Press(1968)ISBN:0 521 35732 2.
4. Wilson A Sutherland: Introduction to Metric and Topological Spaces(2/e) Oxford University Press (2009) ISBN:978-0-19-956308-1.
5. Mohamed A. Khamsi and William A. Kirk: An Introduction to Metric.
6. Spaces and Fixed-Point Theory John Wiley & Sons, Inc (2001) ISBN 0-471- 41825-0

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU6DSEMAT303 CRYPTOGRAPHY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU6DSEMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching these chapters is to provide students with a solid foundation in both the theoretical principles and practical applications of cryptography, preparing them to understand, implement, and analyze cryptographic algorithms and protocols in various contexts, including communication security, data protection, and authentication

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will gain a solid understanding of the fundamental principles of cryptography, including encryption, decryption, key generation, and cryptographic protocols.
CO2	Students will learn about classical encryption techniques such as substitution ciphers and transposition ciphers, as well as basic cryptanalysis techniques for breaking these ciphers
CO3	Students will become proficient in symmetric-key encryption algorithms, including block ciphers and stream ciphers, understanding their design principles, modes of operation, and practical implementations
CO4	Students will master public-key encryption algorithms such as RSA, ElGamal, and elliptic curve cryptography, including key generation, encryption, decryption, digital signatures, and the underlying mathematical principles

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Some Simple Cryptosystems; Introduction, The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream Ciphers (Section 1.1 of Chapter 1 in the Text).

Module 2: Shannon's Theory; Introduction, Elementary Probability Theory, Perfect Secrecy, Entropy, Huffman Encodings and Entropy, Properties of Entropy, Spurious Keys and Unicity Distance, Product Cryptosystems (Chapter 2 in the Text).

Module 3: More on Number Theory; The Euclidean Algorithm, The Chinese Remainder Theorem, Other Useful Facts (Proof of Lagrange's theorem omitted), Legendre and Jacobi Symbols (Sections 5.2 and 5.4.1 of Chapter 5 in the Text).

Module 4: -The RSA System and Factoring ; Introduction to Public-key Cryptography, The RSA Cryptosystem, Implementing RSA, Primality Testing, The Solovay Strassen Algorithm, The Miller Rabin Algorithm, Square roots modulo n (Sections 5.1, 5.3, 5.4.2, 5.4.3, 5.5 of Chapter 5 in the Text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book:

Douglas R. Stinson, Cryptography: Theory and Practice- Third Edition, CRC Press, 2006.

Reference Books:

1. David M. Burton, Elementary Number Theory- Seventh Edition, Mc Graw Hill.

2. William Stallings, Cryptography and Network Security Principles and Practices- Fourth Edition, Prentice Hall.

3. Christof Paar-Jan Pelzl, Understanding Cryptography- A Text for Students and Practitioners, Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

KU7DSCMAT401 ALGEBRA III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main goal of this course is to introduce and discuss some advanced topics in group theory. The main topic covered in this course is the Sylow theorems which provides a partial converse to the Lagrange's theorem. This course also introduces the generalization of direct products and some particular classes of groups which will establish an inclusion order among all groups.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	From the quick review of group theory, students can understand complete structure of subgroups of Dihedral groups, Symmetric groups and Quaternion groups.
CO2	Understand the concept of group actions and its application to counting problems occurs in real life.
CO3	Students would become proficient in understanding Sylow theorems and in finding whether a group is simple or not and there by classifying groups of finite order
CO4	They can understand generalizations of direct products and some special types of groups such as solvable and nilpotent groups.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick review of group theory (Sections 1.1 – 1.6, 2.1 – 2.5 of the text book).

Module 2: Quotient groups and homomorhisms – Definition and Examples, More on Cosets and Lagrange's

Theorem, The Isomorphism Theorems, Composition Series and the Holder Program, Transpositions and the Alternation groups (Sections 3.1 – 3.5 of the text book).

Module 3: Group actions – Group actions and Permutation Representations, Groups Acting on Themselves by Left Multiplication – Cayley's Theorem, Grous Acting on Themselves by Conjugation – The class equation, Automorphisms, The Sylow Theorems, The Simplicity of A_n (without proof) (Sections 1,7, 4,1 – 4.5 of the text book).

Module 4: Further topics in group theory – Review of direct products, semidirect products, p-groups, Nilpotent groups, Solvable groups, Free groups (Section 5.1, 6.1 and 6.3 of the text book).

Text Book: 1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

Reference Books:

1. J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003).
2. I.N. Herstein – Topics in Algebra- Wiley Eastern.
3. J.A.Gallian – Contemporary Abstract Algebra.
4. Hoffman & Kunze – Linear Algebra – Prentice Hall.
5. M. Artin, Algebra, Prentice Hall, 1991.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU7DSCMAT402 LINEAR ALGEBRA III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCMAT402	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective is to provide students with a comprehensive understanding of advanced topics in linear algebra, preparing them for further study in mathematics, engineering, and other related fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will grasp the concept of linear transformations between vector spaces and understand how they relate to matrices.
CO2	Through the study of elementary matrix operations and systems of linear equations, students will become adept at solving such systems using methods like Gaussian elimination and Gauss-Jordan elimination.
CO3	They will be able to compute determinants efficiently and use them to solve systems of linear equations, compute inverses of matrices, and understand geometric concepts such as volume.
CO4	They will be able to work with orthonormal bases, orthogonal complements, and projections, which are essential in various applications such as signal processing, optimization, and quantum mechanics

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Vector spaces (Quick review), Linear Transformations, The Algebra of Linear Transformations Isomorphism (Chapter 2, Chapter-3; Sections 3.1, 3.2,3.3 of the text book 1).

Module 2: Representation of Transformation by Matrices, Linear Functionals, The Double Dual the Transpose of a Linear Transformation. (Chapter 3, sections 3.4, 3.5, 3.6, 3.7 of the text book 1).

Module 3: Elementary Canonical Forms: Introductions, Characteristic Values Annihilating Polynomials, Invariant Subspace (Chapter-6: Sections 6.1, 6.2, 6.3, 6.4 of the text book 1).

Module 4: Jordan Canonical form and applications (Chapter 5, 5.1 to 5.3 of the text book 2) Inner Product Spaces: Inner Products, Inner Product Spaces, (Chapter-8: Sections 8.1, 8.2 of the text book 1).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Books:

1. Kenneth Hoffman & Ray Kunze; Linear Algebra; Second Edition, Prentice-Hall of India Pvt. Ltd
2. D W Lewis, Matrix Theory, World Scientific

Reference Books:

1. Serge A Lang: Linear Algebra; Springer
2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.
3. Thomas W. Hungerford: Algebra; Springer 1980
4. S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition
5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.
6. S. Axler Linear Algebra Done right, Springer

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU7DSCMAT403 REAL ANALYSIS-III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Gaining a comprehensive understanding of advanced real analysis , which is the primary means of comprehending higher mathematics is the primary goal of this course

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Determine if a particular function on a metric space is continuous or not, as well as distinguish between countable and uncountable sets
CO2	Possess the ability to recognize differentiable functions as well as the continuity of derivatives. Also able to understand the various applications of the mean value theorem with clarity as well
CO3	Will gain understanding of Reiman Stieltjes integrals and be able to calculate a function's integral if it is integrable.
CO4	Will gain understanding of the notion of the series of functions' point-wise and uniform convergence.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Basic Topology, Continuity.

Module 2: Differentiation.

Module 3: Riemann – Stieltjes integral.

Module 4: Sequences and series of functions.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1 and 2.

Text Book: Walter Rudin – Principles of Mathematical Analysis (3rd edition) – McGraw Hill, Chapters2,4, 5,6, and 7(up to and including 7.27 only).

Reference Books:

1.T.M. Apostol – Mathematical Analysis (2nd edition) –Narosa.

2. B.G. Bartle – The Elements of Real Analysis – Wiley International.

3. G.F. Simmons – Introduction to Topology and Modern Analysis – McGraw Hill.

4. Pugh, Charles Chapman: Real Mathematical Analysis, springer, 2015.

5. Sudhir R. Ghorpade , Balmohan V. Limaye, A Course in Calculus and Real Analysis (Undergraduate Texts in Mathematics), springer, 2006.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU7DSCMAT404 TOPOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU7DSCMAT404	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The Course aims Introduction to topological spaces. Emphasize the role of basis and sub basis in a topological space. Discuss the properties like connectedness, compactness and separation axioms in topological spaces. Identify homeomorphic objects.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Recognize closed and open sets within a specific topological space. Comprehend the idea of topological spaces and the basis of a topology
CO2	Able to determine if a particular function is continuous or not between two topological spaces. Also capable of understanding the notions of product and metric topologies
CO3	Capable of recognizing compact and connected topological spaces
CO4	Able to provide examples of topological spaces meeting various separation axioms

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Topological spaces, Basis for a topology, The order topology, The product topology(finite),The subspace Topology, Closed sets and limit points,(sections 12 to 17).

Module 2: Continuous functions, The product topology, The metric topology, The metric topology (continued),The quotient topology (Sections 18-22).

Module 3: Connected spaces, Connected subspace of the real line, Compact spaces, compact subset of the real line (sections 23,24, 26, 27).

Module 4: The countability axioms, The separation axioms, Normal spaces, The Urysohn lemma, The Urysohn Metrization Theorem (without proof), Tietze extension Theorem (without proof), The Tychonoff theorem (without proof) (sections 30, 31, 32, 33,34, 35, 37).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1 and 2.

Textbook: J.R. Munkres – Topology, Second edition Pearson India, 2015.

Reference Books:

1. K Parthasarathy, Topology an invitation, Springer (2022).
2. K.D. Joshi – Introduction to General Topology, New age International (1983).
3. G.F. Simmons–Introduction to Topology & Modern Analysis–McGrawHill.
4. M.Singer and J.A. Thorpe – Lecture Notes on Elementary Topology and Geometry, Springer Verlag 1967.
5. Kelley J.L. – General Topology, von Nostrand.
6. Stephen Willard – General Topology, Dover Books in Mathematics.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Semester 7 Electives)

KU7DSEMAT401 ALGEBRAIC NUMBER THEORY

Semester	Course Type		Course Level	Course Code	Credits	Total Hours
7	ELECTIVE		400	KU7DSEMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective is to provide a gentle introduction to the fundamental concepts of algebraic number theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will get a basic introduction and motivation into the subject.
CO2	Will get a knowledge about the historical background and basics of quadratic fields, cyclotomic fields and concepts of factorization.
CO3	Will get knowledge about unique and non-unique factorizations, prime factorization and Euclidean quadratic fields.
CO4	Knowledge of ideals, prime factorization, factorization in cyclotomic fields, lattices are obtained.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Algebraic background, Symmetric Polynomials, modules, Free abelian groups, Algebraic numbers, Conjugates and discriminants, algebraic integers, integral basis, norms and traces, Rings of integers. (Sections 1.4-1.6, 2.1-2.6 of the text book).

Module 2: Quadratic fields. Cyclotomic fields. Factorization into irreducible: Historical back ground. Trivial factorization int irreducible (Sections 3.1, 3.2, 4.1-4.3 of the text book).

Module 3: Examples of non-unique factorization into irreducible. Prime factorization, Euclidean domains, Euclidean quadratic fields. Congruences of unique factorization Ramanujan-Nagell theorem. (Sections 4.4-4.9 of the text book)

Module 4: Ideals, Historical background, Prime factorization of ideals. The norm of an ideal. Non-unique factorization in cyclotomic fields. Lattices. The quotient torus. (Sections 5.1-5.4, 6.1, 6.2 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: N. Stewart & D.O.Tall-Algebraic Number Theory (2nd edn.) Chapman & Hall (1987)

Reference Books:

1. P.Samuel- Theory of Algebraic numbers-Herman Paris Houghton Mifflin (1975).
2. S Lang-Algebraic Number Theory-Addison Wesley (1970).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU7DSEMAT402 ANALYTIC NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSEMAT402	4	90

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to provide an introduction to analytic number theory. Prime number theorem and Dirichlet's theorem on primes in arithmetic progressions are discussed.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students understands the fundamental theorem of arithmetic there by understanding prime numbers. Arithmetical functions like divisor function, Euler totient functions and their Dirichlet product is discussed.
CO2	Averages of arithmetical functions is studied. Chebyshev function is introduced and its relation with prime number distribution is discussed. Main outcome of this chapter is the understanding of the famous prime number theorem
CO3	The congruence relation between numbers is discussed and the famous Euler – Fermat theorem is studied. Some group theoretical aspects of finite abelian groups and their characters are studied in the perspective of number theory.
CO4	The Dirichlet theorem of infiniteness of prime n umbers in discussed. Periodicity of arithmetic functions and the Gauss sum of a Dirichlet character is studied.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The Fundamental theorem of Arithmetic, Arithmetical functions and Dirichlet multiplications.

Module 2: Averages of arithmetical functions. Some elementary theorems on the distribution of prime numbers.

Module 3: Congruences, Finite abelian groups and their characters.

Module 4: Dirichlet's theorem on primes in arithmetic progressions. Periodic Arithmetical Functions and Gauss sums.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Tom M. Apostol - Introduction to Analytic Number Theory (Springer International Edn. 1998) Relevant portions from Chapters 1-8.

Reference Books:

1. G.H.Hardy & Wright Introduction to Theory of Numbers (Oxford) 1985

2. H.Davenport- The Higher Arithmetic (Cambridge) (6th edn.) 1992.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU7DSEMAT403 NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU7DSEMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of the course is to give an introduction to basic concepts of elementary number theory in a combinatorial approach. Both multiplicative and additive problems are discussed.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	This module is intended to learn basic concepts and results in number theory including Fermat's little theorem, Wilson's theorem and Chinese remainder theorem
CO2	This module aims to understand Euler phi function, mobiles inversion formula and Tchebychev's theorem
CO3	This module gives an idea of quadratic congruences, Legendre symbols and quadratic residues.
CO4	This module deals with the elementary partition theory, Euler's partition theorem and partition generation functions

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Basic representation theorem. The fundamental theorem of arithmetic; combinatorial and computational number theory: Permutations and combinations, Fermat's little theorem, Wilson's theorem, generating functions; Fundamentals of congruences- Residue systems, Riffling; Solving congruences- Linear congruences, Chinese remainder theorem, Polynomial congruences. (Chapters 1-5 of the Text

Book).
Module 2: Arithmetic functions- combinatorial study of phi (n), Formulae for d (n) and sigma (n), multivariate arithmetic functions, Mobius inversion formula; Primitive roots- Properties of reduced residue systems, Primitive roots modulo p; Prime numbers- Elementary properties of Pi (x), Tchebychev's theorem. (Chapters: 6 - 8 of the Text Book).

Module 3: Quadratic congruences: Quadratic residues- Euler's criterion, Legendre symbol, Quadratic reciprocity law; Distribution of Quadratic residues- consecutive residues and nonresidues, Consecutive triples of quardratic residues. (Chapters: 9 - 10 of the Text Book).

Module 4: Additivity: Sums of squares- sums of two squares, Sums of four squares; Elementary partition theory- Graphical representation, Euler's partition theorem, searching for partition identities; Partition generating functions- Infinite products as generating functions, Identities between infinite series and products. (Chapters: 11 - 13 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: George E Andrews: Number Theory, Dover Publications (1971) Chapter1 Section1.2, Chapters 2-13.

Reference Books:

1. Andre Weil-Basic Number Theory (3rd edn.) Springer-Verlag (1974).
2. Grosswald, E.-Introduction to Number Theory Brikhauser (2nd edition) 1984.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

KU8DSCMAT401 FUNCTIONAL ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU8DSCMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of the course is to the study some of the features of bounded operators in Banach spaces and Hilbert spaces. Discusses the fundamental results like Hahn- Banach Theorem, Closed graph Theorem, Open mapping Theorem and their consequences

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to analyse properties vector spaces, normed spaces, and Banach spaces, including the properties and characteristics that define these mathematical structures
CO2	Students will get the ability to analyse and manipulate linear operators algebraically and apply them to solve problems in functional analysis
CO3	Students will demonstrate proficiency in the representation of functionals on Hilbert spaces, showcasing their ability to work with Hilbert-Adjoint operators, and analyse the properties of self-adjoint, unitary, and normal operators. They will be able to apply these concepts to represent various classes of operators and functionals, highlighting their importance in functional analysis
CO4	Students will get proficiency in understanding and working with adjoint operators, reflexive spaces, and various convergence concepts, including strong and weak convergence.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Vector space, Normed space, Banach space, Further Properties of Normed spaces, Finite dimensional normed spaces and subspaces, compactness and finite dimension, linear operators, Bounded and continuous linear operators, linear functionals (Section 2.1 to 2.8 of the Text book).

Module 2: Linear operators and functionals on finite-dimensional spaces, normed spaces of operators. Dual space, (up to 2.10.6), Inner Product spaces. Hilbert spaces, Further properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, series related to orthonormal sequences and sets (Definitions and statement of results), total orthonormal sets and sequences (up to 3.6.4), Legendre, Hermite and Laguerre Polynomials (Definitions), (Section 2.9 to 3.7of the Text book).

Module 3: Representation of Functionals on Hilbert spaces, Hilbert-Adjoint operator, Self-adjoint, unitary and normal operators, Zorn's lemma, Hahn-Banach theorem, Hahn-Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functional on C[a,b] (Definitions only), (section 3.8 to 4.4of the Text book).

Module 4: Adjoint operator (4.5, up to 4.5.2), Reflexive spaces (4.6, Definitions), Category Theorem, Uniform Boundedness Theorem (4.7.1-4.7.3), Strong and weak convergence (4.8, up to 4.8.3), Open mapping theorem (4.12), closed linear operators, closed graph theorem (4.13).(sections 4.5 (up to 4.5.2) to 4.8.3, 4.12 to 4.13of the Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: E. Kreyszig, Introductory Functional Analysis with Applications (Wiley).

Reference Books

1. B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
3. M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014.
4. R. Bhatia: Notes on Functional Analysis TRIM series, Hindustan Book Agency,
5. Kesavan S: Functional Analysis TRIM series, Hindustan Book Agency, 2009
6. George Bachman & Lawrence Narici: Functional Analysis, Dover books on mathematics (1966, 2000)
7. Yuli Eidelman, Vitali Milman, and Antonis Tsolomitis, : Functional analysis An Introduction. Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU8DSCMAT402 MEASURE AND INTEGRATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU8DSCMAT402	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main aim is to get a clear picture of the abstract measure theory and Lebesgue integral, which are essential for the study of advanced analysis

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students are able to: understand the reason for the development of Lebesgue integral in comparison with the Reimann integral. Also, will get an idea of measure and measure space
CO2	Will get an idea on how the Lebesgue integral of measurable functions can be computed. Will get an idea of the concept of L_p spaces
CO3	Will get the concept of convergence in measure and almost uniform convergence. Two important theorems viz Egoroff's theorem and Vitali convergence theorem are stated and proved
CO4	Will learn the different ways of decomposing measures and charges. Also learn how to construct Lebesgue measure on the real line from the length of an interval

Mapping of COs to PSOs

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction. Measurable functions. Measures

Module 2: The integral. Integrable functions. Lp – spaces

Module 3: Modes of convergence

Module 4: Generation of measures. Decomposition of measures

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: R.G. Bartle – The Elements of Integration (1966), John Wiley & Sons (Chapters 1 to 10)

Reference Books:

1. H.L. Royden – Real Analysis –Macmillan.
2. de Barra – Measure and Integration.
3. Inder K. Rana – Measure and Integration – Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU8DSCMAT403 ORDINARY DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU8DSCMAT403	4	90

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to understand and analyze the solutions of some important types of ODEs. This serves as an important path from mathematics to physics and engineering

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Get a proper understanding about existence and uniqueness of solutions of first order ODE
CO2	Able to understand the existence of power series solutions and get used to the problem solving
CO3	Able to learn about some very important special functions of mathematical physics
CO4	Able to get an understanding about nonlinear ODE and its solutions.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Population growth model, An atomic waste disposal problem, Review of Chapter 1, 2 and 3 of reference 4 in connection with Chapter 3 of the Text Book (Chapter 1: Sections – 1.2.1, 1.2.2, Chapter 3(review)).

Module 2: Sufficient condition for uniqueness of solution, Sufficient condition for existence of solution, Continuous dependence of the solution on initial data and dynamics, Continuation of a solution into larger intervals and maximal interval of existence, Existence and uniqueness of a system of equations (Chapter 4, Section 4.1 - 4.7).

Module 3: General n-th order equations and and linear systems, Autonomous homogeneous systems, Two-dimensional systems, Stability analysis, Higher dimensional systems, Invariant subspaces, Non homogeneous autonomous systems (Chapter 5, Sections 5.1 – 5.8.).

Module 4: Real analytic functions, Equations with analytic coefficients, Regular singular, Basic result and orthogonality, oscillation results, Existence of eigen functions (Chapter 6, Sections 6.1 – 6.5, 7.1 – 7.5.).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: Ordinary differential equations: Principles and applications by Ian A. K. Nandakumaran, P. S. Datti and Raju K. George Cambridge University Press, 1983).

Reference Books:

1. Differential equations with applications and historical notes by George F. Simmons (CRC Press, Third Edition, 2017).
2. An introduction to ordinary differential equations by Earl A. Coddington (Dover Books, 1989).
3. Ordinary differential equations by Birkhoff G. and G. C. Rota (Wiley, 1989).
4. Elementary differential equations and boundary value problems by W. E. Boyce and R. C. DiPrima, John Wiley and Sons (2009).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Semester 8 Electives)

KU8DSEMAT401 CODING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSEMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim is to provide an introduction to the fundamental concepts of coding theory

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	By studying these concepts empowers students, to design, analyses, and implement error-correcting codes for reliable communication systems. They develop problem-solving skills, mathematical reasoning abilities, and a deep understanding of the principles underlying modern digital communication technology.
CO2	Equips students with advanced knowledge and skills in designing, analyzing, and implementing error-correcting codes for reliable communication systems.
CO3	Studying these advanced topics in coding theory equips students with the knowledge, skills, and analytical abilities needed to design, analyze, and implement sophisticated coding schemes for reliable and efficient communication systems
CO4	Studying BCH codes, decoding algorithms for BCH codes, Reed-Solomon codes, and related topics provides students with a strong foundation in advanced coding techniques and prepares them for careers in fields where error-correction coding is essential for ensuring reliable and efficient communication and storage of digital information.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Coding Theory. Correcting and detecting error patterns. Weight and distance. MLD and its reliability. Error-detecting codes. Error correcting codes. Linear codes (Chapter 1 of the Text and sections 2.1 to 2.5 of chapter 2 of the text).

Module 2: Generating matrices and encoding. Parity check matrices. Equivalent codes. MLD for linear codes. Reliability of IMLD for linear codes, Some bounds for codes, Perfect codes, Hamming codes. Extended codes extended Golay code and Decoding of extended Golay code (Sections 2.6 to 2.12 of Chapter 2 and sections 3.1 to 3.6 of chapter 3of the text).

Module 3: The Golay code, Reed-Muller codes, Fast decoding of RM (1, m), Cyclic linear codes. Generating and parity check matrices for cyclic codes. Finding cyclic codes. Dual cyclic codes (Sections 3.7 to 3.9 of Chapter 3 and Chapter 4 complete.

Module 4: BCH codes. Decoding 2-error-correcting BCH code. Reed-Solomon codes. Decoding (Chapter 5 complete and sections 6.1, 6.2 and 6.3 of chapter 6).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Coding Theory and Cryptography the Essentials (2nd edition) – D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger and J. R. Wall – Marcel Dekker (2000).

Reference Books:

1. J. H. van Lint – Introduction to Coding Theory – Springer Verlag (1982)
2. E. R. Berlekamp – Algebraic Coding Theory – McGraw Hill (196

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU8DSEMAT402 REPRESENTATION THEORY OF FINITE GROUPS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSEMAT402	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to give an introduction to representation theory. Representation theory is an area of mathematics which studies symmetry in linear spaces. The theory, roughly speaking, is a fundamental tool for studying symmetry by means of linear algebra.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	It introduces the definition of representations of a finite group and there by introduces the notion of group modules. Some basics theorems are also discussed
CO2	This chapter introduces the crucial notion of orthogonality relations between representations, character table. Also, representation theory of finite abelian group is more specifically understood
CO3	It introduces the concepts of induced and discusses the Frobenius law of reciprocity which relates inner products of restricted and induced characters.
CO4	Students will learn the crucial notion of orthogonality relations between representations, character table. Also, representation theory of finite abelian group is more specifically understood.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction, G- modules, Characters, Reducibility, Permutation Representations, Complete reducibility, Schur's lemma, The commutant (endomorphism) algebra. (Sections:1.1 to 1.8of the text book).

Module 2: Orthogonality relations, the group algebra, the character table, finite abelian groups, the lifting process, linear characters. (section: 2.1 to 2.6of the text book).

Module 3: Induced representations, reciprocity law, the alternating group A_5, Normal subgroups (Sections: 3.1 to 3.4 of the text book).

Module 4: Transitive groups, the symmetric group, induced characters of S_n. (Sections: 4.1 to 4.3of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Walter Ledermann, Introduction to Group Characters, Cambridge university press 1087. (Second Edition).

Reference Books:

1. C. W. Kurtis and I. Reiner, Representation Theory of Finite Groups and Associative Algebras. American Mathematical society 2006.
2. Algebras, John Wiley & Sons, New York (1962) W Fulton, J. Harris, Representation Theory, A first course. Springer 2004.
3. Fulton, The Representation Theory of Finite Groups, Lecture Notes in Mathematics, No. 682, Springer 1978.
4. C. Musli, Representations of Finite Groups, Hindustan Book Agency, New Delhi (1993)
5. J.P. Serre, Linear Representation of Finite Groups, Graduate Text in Mathematics, Vol 42, Springer (1977).
6. Bruce E Sagan, The symmetric group – Representations, combinatorial algorithms and symmetric functions.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU8DSEMAT403 FUZZY MATHEMATICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU8DSEMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to provide an introduction to the fundamental concepts of Fuzzy Mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to comprehend the similarities and distinctions between crisp sets and fuzzy sets
CO2	Students will develop an understanding of the fundamental concepts of union and intersection within fuzzy sets, enabling them to effectively navigate the nuances of set operations in fuzzy environment
CO3	Students will gain a comprehensive understanding of the concept of fuzzy relations, including an exploration of various types of fuzzy relations and the operations involved in manipulating them
CO4	Provides students with insight into the limitations of classical two-valued logic in addressing the imprecision, uncertainty, and complexity inherent in the real world. It also introduces the concepts of multi-valued logic and fuzzy logic, offering a broader perspective on handling such complexities effectively.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: From classical (crisp) sets to fuzzy sets: characteristics and significance of the paradigm shift. Additional properties of α-cuts. Representation of fuzzy sets. Extension principle for fuzzy sets. (Chapters. 1 & 2 of the Text Book).

Module 2: Operations on fuzzy sets. Types of operations. Fuzzy complements. t-norms, t-conorms. Combinations of operations. Aggregate operations, Fuzzy numbers Arithmetic operations on intervals. Arithmetic operations on fuzzy numbers. Lattice of fuzzy numbers (Sections 3.1 to 3.4 of Chapters. 3 of the Text and sections 4.1 to 4.5).

Module 3: Crisp and fuzzy relations, projections and cylindric extensions, binary fuzzy relations, binary relations on a single set, Fuzzy equivalence relations, Compatibility and ordering relations. Fuzzy morphisms. sup-i, inf- ωI compositions of fuzzy relations. (Sections 5.1 to5.6 and sections 5.8 to 5.10 of chapter 5 of the text book).

Module 4: Fuzzy logic. Fuzzy propositions. Fuzzy quantifiers. Linguistic hedges. Inference from conditional, conditional and qualified and quantified propositions (Chapter 8 of the text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Fuzzy sets and Fuzzy logic Theory and Applications – G. J. Klir & Bo Yuan – PHI (1995)

Reference Books:

1. Zimmermann H. J. – Fuzzy Set Theory and its Applications, Kluwer (1985).
2. Zimmermann H. J. – Fuzzy Sets, Decision Making and Expert Systems, Kluwer (1987).
3. Dubois D. & H. Prade – Fuzzy Sets and Systems: Theory and Applications – Academic Press (1980).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

KU9DSCMAT501 ALGEBRA IV

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU9DSCMAT501	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The main goal of this course is to give a complete description of Galois theory. The main tool for the discussion is the theory of extension fields and factorization of polynomials in the rings of polynomials.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand the concept of field of quotients of integral domain, Euclidean domain, principal ideal domain and unique factorization domain which are generalizations of the well-known polynomial rings
CO2	Understand a complete structure of polynomial rings and factorization of polynomials.
CO3	Students would learn field extensions, algebraically closed fields and hence about the existence of roots of polynomials
CO4	The students will understand the important Galois theory and computation of Galois group of polynomials

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Review of Ring theory, Rings of fractions (Sections 7.1 to 7.4, 7.5).

Module 2: Euclidean domain, Principal Ideal domains, Euclidean Domains, Revisit of polynomial rings (Sections 8.1-8.3, 9.1 – 9.4).

Module 3: Basic Theory of Field Extensions, Algebraic Extensions, Classical Straightedge and Compass Constructions, Splitting Fields and Algebraic Closures, Separable and Inseparable Extensions, Cyclotomic Polynomials and Extensions (Sections 13.1 – 13.6, of Text book).

Module 4: Basic definitions, The Fundamentals of Galois Theory, Finite Fields, Composite Extensions and Simple Extensions, Cyclotomic Extensions and Abelian Extensions over Q. (Sections 14.1 – 14.5).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: 1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

Reference Books:

1. J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003
2. I.N. Herstein – Topics in Algebra- Wiley Eastern
3. J.A.Gallian – Contemporary Abstract Algebra
4. Hoffman & Kunze – Linear Algebra – Prentice Hall
5. M. Artin, Algebra, Prentice Hall, 1991

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU9DSCMAT502 COMPLEX ANALYSIS III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU9DSCMAT502	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: This course gives a foundation to the theory of complex numbers. Assuming the prerequisites on the algebraic and topological properties of complex numbers, this course begins by introducing the integration of complex valued functions across curves in the plane, analyticity, power series representation of analytic functions, bounds of analytic function and a description and classification of points at which a complex function loss its analyticity.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to interpret and work with the extended plane, gaining proficiency in understanding its topological properties and how it is represented on the sphere. Students will develop a comprehensive understanding of power series, analytic functions, Cauchy Riemann equations, how analytic functions serve as mappings between complex planes. They will be able to analyze the behavior of these mappings, including the preservation of angles and conformal properties
CO2	Students will develop a deep understanding of Riemann-Stieltjes integrals, power series representation of analytic functions including the theory behind the integration of functions. They will investigate the properties of zeros of analytic functions, understanding the relationship between the zeros and the behavior of the function. Also develop a solid understanding of the index of a closed curve in the complex plane. They will be able to calculate the index using various methods, such as the winding number and contour integration
CO3	Students will demonstrate proficiency in applying advanced concepts such as Cauchy's theorem homotopic version of Cauchy's Theorem, Schwarz's Lemma, and Goursat's Theorem, counting zeros of analytic functions and open mapping theorem. They will be able to analyze regions in the complex plane, determine simple connectivity, and establish properties of holomorphic functions using these concepts.
CO4	Students will develop a comprehensive understanding of singularities in complex functions and their classification into removable, poles, and essential singularities. They will also master the calculation of residues, maximum principle, Schwarz's Lemma and its implications for holomorphic functions. They will understand how this lemma provides information about the mapping properties of holomorphic functions on the unit disk.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The extended plane and its spherical representation, power series, analytic functions, Analytic functions as mapping, Mobius transformations ((Chapter I -6, Chapter III – 1,2, and 3)).

Module 2: Riemann Stieltjes integrals, power series representation of analytic functions, Zeros of an analytic function, index of a closed curve (Chapter IV – 1,2,3 and 4).

Module 3: Cauchy's theorem and integral formula, homotopic version of Cauchy's theorem and simple connectivity, counting zeros- open mapping theorem, Goursat theorem (Chapter IV - 5,6,7,8 Omit the proof of third version of Cauchy's theorem).

Module 4: Classification of singularities, residues, argument principle, maximum principle, Schwarz lemma (Chapter V – 1,2,3, Chapter VI – 1,2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book : Conway J.B. – Functions of One Complex Variable I – Second edition , Springer international student edition.

References:

1.J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mcgraw-Hill,(2009).
2.W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987.
3. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford.
4. S Lang - Complex Analysis, Fourth Edition, Grauate texts in Mathematics 103, Springer, Second Indian Reprint 2013.
5. Herb Silverman - Complex Variabies,Houghton Mifflin Co., 1975.
6. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007.
7. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU9DSCMAT503 FUNCTIONAL ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU9DSCMAT503	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objective: The objective of this course is to delve into the spectral theory concerning both compact linear operators and bounded self-adjoint linear operators.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will able to Understand approximation methods and techniques in normed spaces, which allows for the approximation of functions or elements by simpler or more manageable ones
CO2	Able to understand spectral properties, which is crucial for analyzing linear operators in various contexts, including differential equations and quantum mechanics
CO3	Will get knowledge of spectral properties, which helps in characterizing the eigenvalues, eigenvectors, and spectrum of compact operators, enabling their use in solving integral equations, Fredholm theory, and approximation problems
CO4	Will get good Knowledge of positive operators allows for the analysis of positivity-preserving transformations and the study of properties such as monotonicity, convexity, and order structures.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Approximation in normed spaces, Uniqueness, strict convexity, Uniform approximation, Approximation in Hilbert space, Spectral Theory in finite dimensional normed spaces, Basic concepts, (Section 6.1, 6.2, 6.3, 6.5, 7.1 & 7.2 of the Text Book).

Module 2: Spectral properties of bounded linear operators, Further properties of resolvent and spectrum, Use of complex analysis in spectral theory, Banach algebras, Further properties of Banach algebras, compact linear operators on normed spaces, Further properties of compact linear operators (7.3 to 8.2 of the Text Book).

Module 3: Spectral properties of compact linear operators on normed spaces, further spectral properties of compact linear operators, Operator equations involving compact linear operators, spectral properties of bounded self-adjoint linear operators, further spectral properties of bounded self-adjoint linear operators (section 8.3 to 8.5 & 9.1 to 9.2of the Text Book).

Module 4: Positive operators, square root of a positive operator, projection operators, further properties of projections, spectral family, spectral family of a bounded self-adjoint linear operators, spectral representation of bounded self-adjoint linear operators. (sections 9.3 to 9.9 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book : E. Kreyszig, Introductory Functional Analysis with Applications (Wiley)

Reference Books

1 B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014.
2. M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014.
3. R. Bhatia: Notes on Functional Analysis TRIM series, Hindustan Book Agency, 2009
4. Sunder V.S.: Functional Analysis spectral theory, TRIM Series, Hindustan Book Agency,1997
5. George Bachman & Lawrence Narici: Functional Analysis, Dover books on mathematics (1966, 2000)
6 . Yuli Eidelman, Vitali Milman,and Antonis Tsolomitis, : Functional analysis An Introduction, Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU9DSCMAT504 FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAL GEOMETRY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU9DSCMAT504	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The course gives an introduction to the elementary concepts of differential geometry using the calculus of vector fields so that the students also attain a deep understanding of several variable calculus.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The main aim of this module is to get a proper understanding of the functions of several variables and the differentiation of such function
CO2	This module is intended to make students comfortable in the preliminaries of differential geometry. The students are expected to understand graphs, level sets, tangent spaces and surfaces.
CO3	This module is intended to understand important concepts such as Weingarten map and curvature. As a first step to understand the curvature of surfaces, it is important to learn about the curvature of plane curves
CO4	This module deals with line integrals and curvature of surfaces. These are the most important objectives of this differential geometry course

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Functions of Several variables (Text 1, Chapter 9, Sections 1-29).

Module 2: Surfaces and vector fields:(Text 2, Chapters 1-6).

Module 3: Weingarten map and curvature (Text 2, Chapters 7-10).

Module 4: Curvature of surfaces:(Text 2, Chapters 11-12).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book 1: Principles of Mathematical Analysis by W. Rudin (Mc.Graw Hill, 1986).

Text Book 2: Elementary Topics in Differential Geometry by J. A. Thorpe (Springer-Verlag, 2011).

Reference Books:

1. Elementary Differential Geometry by Andrew Pressley (Springer-Verlag, 2010)
2. Differential geometry of Curves and Surfaces by M. P. do Carmo (Dover Publications, 2016)
3. Mathematical Analysis by T. M. Apostol (Pearson, 1974).
4. Analysis on Manifolds by james R. Munkres (Addison-Wesley Publishing Company, 1991)

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU9DSCMAT505 PARTIAL DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU9DSCMAT505	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to familiarize the students with fundamental concepts of partial differential equations

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The aim of this module is to get familiar with the first order PD
CO2	This module is intended to learn the second order PDE and its classification
CO3	The aim of this module is to learn the well known PDE problems such as heat and Laplace equations
CO4	This module is focusing on the study of wave equations

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: First Order Partial Differential Equations: Method of Characteristics (Chapter 3: Sections - 3.1, 3.2, 3.3, 3.4 and 3.5 of the Text Book).

Module 2: Classification of second Order PDE (Chapter 6: Sections - 6.1, 6.2, 6.3 and 6.4of the Text Book).

Module 3: Laplace and Heat Equation (Chapter: Sections - 8.1. 8.2 and 8.4 of the Text Book).

Module 4: One Dimensional Wave Equation (Chapter 9: Sections - 9.1, 9.2, 9.3 and 9.4 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book</u>: Partial Differential Equations: Classical Theory with a Modern Touch by A. K. Nandakumaran and P. S. Datti (Cambridge University Press, 2020).

<u>Reference Books:</u>

1. Partial differential Equations by Lawrence C. Evans (American Mathematical Society, 2010).
2. Elements of Partial Differential Equations by Ian Sneddon (McGraw Hill, 1983).
3. An elementary Course in partial differential Equations by T. Amarnath (Narosa Publishing House 2003).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

Dissertation (From institutes of National reputation), Total Credits 20

OR

[5 DSC Courses, each worth 4 credits, comprising one MOOC course at the 500 level and /or a 4-credit internship/minor project]

KU10DSCMAT501 ADVANCED TOPICS IN ANALYSIS

Core

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT501	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: To get an overall knowledge on basic analysis which helps to do further advanced reading in this direction. It also touches the fundamental areas of measure theory, point set topology and Lebesgue spaces so that students get a connection with various tools used in advanced analysis**.**

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The main aim of the first module is to understand the Lebesgue-radon-Nikodym theorem
CO2	The second module is intended to make students comfortable about complex measures and functions of bounded variation
CO3	Third module uses the knowledge the students in basic point set topology and deals with the locally compact Hausdorff spaces and The Stone-Weiersrtrass theorem.
CO4	The fourth module is dealing with Lp spaces mainly. It is expected that after the completion of this module students would be comfortable with some important inequalities, basics of distribution and interpolation

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Signed measures (Chapter 1 and 2 review, chapter 3, Sections - 3.1 - 3.3 of the text book)

Module 2: Differentiation: (Chapter 3, Sections 3.3 -3.5 of the text book)

Module 3: Point set topology: (Chapter 4, Sections 4.1 - 4.7 of the text book)

Module 4: Lebesgue Spaces: (Chapter 6 - Section 6.1 - 6.5 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Real Analysis: Modern Techniques and Their Applications by Gerald B. Folland, Second edition, John Willey and Sons, Inc, 1999

Reference Books:

1. Foundations of Real and Abstract Analysis by D. S. Bridges, GTM Series, Springer Verlag 1997.
2. Real and Complex Analysis by W. Rudin, Tata McGraw.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT502ALGEBRAIC TOPOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT502	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The course discusses simplicial homology theory, the Euler Poincare theorem and the fundamental group. The purpose of this course is to give students the opportunity to see how algebraic concepts or abstract algebra can be used as a tool to learn topology, another branch of mathematics

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The students will grasp how Algebraic Topology elucidates the structure of a topological space by correlating it with algebraic systems, particularly groups
CO2	Students will gain an understanding of homology groups
CO3	Students will learn to compare two topological spaces based on the algebraic similarities between their associated homology groups
CO4	Students will comprehend how the structure of two topological spaces can be explored through the analysis of paths within those spaces.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Geometric complexes and polyhedra. Orientation of geometric complexes.

Module 2: Simplicial homology groups. Structure of homology groups. The Euler-Poincare theorem.

Pseudomanifolds and the homology groups of Sn.

Module 3: Simplicial approximation. Induced homomorphisms on homology groups. Brouwer fixed point theorem and related results.

Module 4: The fundamental groups. Examples. The relation between H1(K) and $\pi 1(|K|)$.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Fred H. Croom – Basic Concepts of Algebraic Topology – Springer Verlag (1978)

Reference Books:

1. Maunder – Algebraic Topology – Van Nostrand-Reinhold (1970).
2. Munkres J.R. – Topology, A First Course – Prentice Hall (1975).
3. Allen Hatcher-Algebraic Topology Cambridge University Press 2002.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT503 HARMONIC ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT503	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Many Branches of Mathematics come together In Harmonic Analysis. Each adding richness to the subject and each giving insights Into the subject. The course is a gentle introduction to Fourier Analysis and Harmonic Analysis.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The student will understand the Dirichlet problem and periodic functions
CO2	The student will about the Fourier series and its convergences
CO3	The student will learn some important notions in functional analysis which is useful to study Fourier analysis
CO4	The student will learn the concept of Fourier transforms.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick review of chapter 0, The Dirichlet Problem for a Disk, Continuous functions on the unit Disc, the method of Fourier, Uniform convergence, the formulas of Euler, Cesaro convergence, Fejer's theorem, at last the solution. Chapters 0 (sections 1 to 8) and 1 of the Text Book.

Module 2: Functions on (-pi, pi), Functions on other intervals, Functions with special properties, pointwise convergence of the Fourier series, (Chapter 2 of the text book).

Module 3: Normed vector spaces, Convergence in normed spaces, inner product spaces, infinite orthonormal sets, Hilbert spaces, the completion, wavelets. (Chapter 3 of the Text Book).

Module 4: The Fourier transform on Z, Invertible elements in l^1(Z), The Fourier transform on R, Finite Fourier transform. Chapter 4 sections 1, 2, 3 and 6 of the Text Book.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book:</u> Carl L. DeVito, Harmonic Analysis, A gentle Introduction.

<u>Reference Books</u> :

1. Yitzhak Katznelson, An Introduction to Harmonic Analysis,

2. Geral B. Folland, a course in abstract harmonic analysis.
3. Anton Deitmar, A first course in harmonic analysis, Springer.
4. Elias M. Stein and Guido Weiss, Introduction to Fourier analysis on Euclidean spaces.
5. Edwin Hewitt; Kenneth A. Ross, Abstract Harmonic Analysis. Springer

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT504 OPERATOR ALGEBRAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT504	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to introduce fundamental topics in operator theory. It is a field that has great importance for other areas of mathematics and physics, such as algebraic topology, differential geometry, quantum mechanics. We discuss the basics results of Banach algebras and C* algebras

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the concepts of functional analysis, including Banach spaces and Banach algebras
CO2	Students will master the Gelfand transform and its applications in the study of Banach algebras
CO3	Students will gain a comprehensive understanding of C* algebras, including their definition, properties, and applications
CO4	Students will comprehend the concept of positive linear functionals and states in the context of C* algebras

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Review on Functional analysis, Banach algebras and the invertible group, The spectrum, Multiplicative linear functional, (Sections 1 to 4).

Module 2: The Gelfand Transform and applications, Examples of maximal ideal spaces, Non-unital Banach algebras, (Sections 5 to 7).

Module 3: C* algebras, Commutative C* algebras, the spectral theorem (up to 10.3), Polar Decomposition (Sections 8, 9, 10, 12).

Module 4: Positive linear functional and states, The GNS construction, non-unital C* algebras, Strong and weak –operator topologies (Sections 13,14,15, 16).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Kehe Zhu, An introduction to operator algebras CRC Press 1993.

Reference Books:

1. Introduction to topology and modern analysis, McGraw Hill Education ,2017.
2. R V Kadison and JR. Ringrose: Fundamentals of the theory of Operator algebras, volume 1, II Academic press, 1983.
3. W. Arveson, An invitation to C* algebras, springer 1998.
4. W. Rudin, Functional analysis, McGraw Hill Education.
5. V S Sunder, An invitation to von Newmann algebras, springer 1998.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT505 INTRODUCTION TO LIE ALGEBRAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT505	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial				
4	1	50	50	100	3Hrs

Course Objectives: This course is mainly designed for a beginner to give a very basic algebraic introduction to the theory of Lie algebras and representation theory. Lie algebras have become essential to many parts of mathematics and theoretical physics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the definition of Lie algebras, examples and some fundamental concepts, including ideals, homomorphisms, derivations and structure constants.
CO2	Students will understand quotient Lie algebras, construction of ideals, small dimensional examples and very basics of Solvable, semisimple and Nilpotent Lie algebras.
CO3	Students will gain a basic idea of representation theory of Lie algebras. They also understand module theory in the context of Lie algebras and some fundamental concepts of modules and discusses the Schur's lemma explaining the structure of a Lie module.
CO4	Students will comprehend the important concept of root system in the Euclidean spaces and they will understand the combinatorial descriptions of root systems of Lie algebras via the Dynkin diagrams.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Definition of Lie Algebras, Some Examples, Subalgebras and Ideals, Homomorphisms, Algebras, Derivations, Structure Constants (Sections 1.1 to 1.7).

Module 2: Construction with Ideals, Quotient Algebras, Correspondence between Ideals, Low – Dimensional Lie Algebras – Dimensions 1 and 2, Dimension 3, Solvable, Semi simple and Nilpotent Lie algebras (Definitions and Examples only) (Sections 2.1 – 2.3, 3.1 and 3.2,4.1 and 4.2).

Module 3: Some representation theory - Definitions, Examples of Representations, Modules for Lie algebras, Submodules and Factor modules, Irreducible and Indecomposable module, Homomorphisms and Schur's Lemma (Sections 7.1 – 7.7).

Module 4: Root systems - Definition of Root Systems, First steps in the Classification, Bases for Root systems, Cartan matrices and Dynkin diagrams (Sections 1.1 – 11.4).

Module 5: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Introduction to Lie algebras - Karin Erdmann and Mark J. Wildon, Springer Undergraduate Mathematics Series.

Reference Books:

1. Introduction to Lie algebras and Representation theory - James E Humphreys.
2. Lie algebras of Finite and Affine Type - Roger Carter.
3. Reflection groups and Coxeter groups - James E Humphreys.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT506 COMMUTATIVE ALGEBRA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT506	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial				
4	1	50	50	100	3Hrs

Course Objectives: This course discusses some advanced topics in algebra more specifically commutative algebra. It discusses a deeper theory of commutative rings. Commutative algebra has mainly developed because of its hardcore applications in Algebraic number theory and Algebraic Geometry. It is very importance in the theory of Homological algebra which plays an important part in modern mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the basic definitions concerning different classes of commutative rings, elements in commutative rings, and ideals in commutative rings and some properties and operations among them. They also understand the important concept of modules over commutative rings and operations on modules.
CO2	Students will understand the concepts of exact sequences, tensor product of modules and algebras and the localization properties.
CO3	Students will understand the decomposition of ideal into primary ideals. They also understand the integral dependence and valuations in a ring.
CO4	Understand the chain conditions of rings and modules and hence the definition and some examples of Noetherian and Artinian rings.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Rings and Ideals; Modules [Chapt I; Chapt II (upto and including `Operations on Submodules)].

Module 2: Modules; Rings and Modules of Fractions (Chapter II (from `Direct Sum and Product'); Chapter III)

Module 3: Primary Decomposition; Integral Dependence and Valuations (Chapter IV; Chapter V).

Module 4: Chain Conditions; Noetherian Rings; Artin Rings (Definition and Examples only) (Chapter VI; Chapter VII; Chapter VIII).

Module 5: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Atiyah M. F. & Macdonald, I.G, Introduction to Commutative Algebra, Addison Wesley, N.Y, (1969).

Reference Books:

1. N. S. Gopalakrishnan: Commutative Algebra, Oxonian Press, 1984.
2. D. Eisenbud: Commutative algebra with a view toward algebraic geometry GTM (150), Springer-Verlag (1995).
3. H. Matsumura: Commutative ring theory, Cambridge Studies in Advanced Mathematics No. 8, Cambridge University Press (1980).
4. R.Y. Sharp: Steps in commutative algebra, LMS Student Texts (19), Cambridge Univ. Press (1995).

5. Miles Reid: Undergraduate Commutative Algebra, Cambridge University Press (1995).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT507 - a MOOC Course for 4 credits of 500 level, from the list provided by the Department Council or/One 4-credit Internship or / 4-credit Minor project (for 100 marks).

KU1MDCMAT101 ELEMENTARY MATHEMATICS-1 (MDC 1)

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU1MDCMAT101	3	45

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
3	1	30	30	60	2Hrs

Course Objectives: The objective is to provide a basic understanding of fundamental mathematical concepts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding real numbers, including rational and irrational numbers. They will apply laws of exponents to solve problems involving powers and roots. Additionally, they will master fundamental operations with polynomials, solve linear equations, and use algebraic identities effectively in practical scenarios.
CO2	Learners will apply ratio and proportion concepts in various real-life scenarios such as scaling, mixing, and comparisons. They will calculate percentages for solving problems related to interest, discounts, and profit-loss situations, thus enhancing their quantitative reasoning skills.
CO3	Students will understand and work with basic geometric shapes, calculating perimeters and areas of simple figures. They will grasp concepts of similarity and congruence, enabling them to analyze and solve geometric problems encountered in everyday life
CO4	By studying statistics and probability, students will gain proficiency in data representation using tables and charts. They will compute measures of central tendency (mean, median, mode) and utilize basic probability concepts. Additionally, learners will acquire fundamental knowledge of financial mathematics including simple and compound interest calculations and budgeting.
CO5	Students will develop logical thinking skills through problem-solving strategies and the application of logical operations (AND, OR, NOT) in various contexts. Optionally, they will be introduced to basic trigonometry, including trigonometric ratios (sine, cosine, tangent) and their applications in solving practical problems like height and distance
CO6	The course will foster an understanding of how mathematics intersects with literature and history. Students will explore mathematical concepts used in historical and literary contexts, recognizing numerical symbolism in literature and analyzing historical data using mathematical tools.
CO7	Learners will master algebraic identities such as (a + b)^2, (a - b)^2, a^2 - b^2 and apply them to factorize algebraic expressions. This will strengthen their algebraic reasoning and problem-solving abilities.

COURSE CONTENTS

Module 1 Number System: Understanding real numbers, rational and irrational numbers, Laws of exponents and their applications, Basic Algebra: Fundamental operations with polynomials (addition, subtraction, multiplication), Solving linear equations in one variable, Understanding simple algebraic identities and their applications.

Module 2 Ratio and Proportion: Concept of ratio and proportion, Applications in scaling, mixing, and comparison problems. Percentage and its Applications: Understanding percentages, calculations involving percentage. Applications in interest, discounts, and profit-loss calculations. Basic Geometry: Understanding basic geometric shapes (lines, angles, triangles, circles). Perimeter and area of simple shapes, Introduction to concepts like similarity and congruence.

Module 3: Statistics and Probability: Basic concepts of data representation (tables, charts), Measures of central tendency (mean, median, mode), Introduction to probability and its practical applications, Financial

Mathematics: Basic understanding of financial calculations such as simple interest and compound interest, Budgeting and personal finance concepts.

Module 4: Logical Reasoning: Introduction to logical thinking and problem-solving strategies, understanding logical operations (AND, OR, NOT) and their applications, Basic Trigonometry (optional, based on curriculum): Introduction to trigonometric ratios (sine, cosine, tangent), Simple applications in solving height and distance problems.

Module X: Mathematical Applications in Literature and History: Exploring mathematical concepts used in historical and literary contexts (e.g., numerical symbolism in literature, historical data analysis), Introduction to Algebraic Identities: Simple identities like (a + b) ^2, (a - b)^2, a^2 - b^2, Factorization of algebraic expressions.

References:

7. Mathematics: A Very Short Introduction, Timothy Gowers:
8. The Joy of x: A Guided Tour of Math, from One to Infinity, Steven Strogatz
9. The Princeton Companion to Mathematics edited, Timothy Gowers

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	30 marks
Continuous Evaluation	
Tests	12 Marks
Assignment	6 Marks
Seminar/Viva	12 Marks
Total	30 Marks

KU2MDCMAT101 ELEMENTARY MATHEMATICS - 2 (MDC 2)

Remark: Course for students who have not studied mathematics at +2 level.

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU2MDCMAT101	3	45

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
3	1	30	30	60	2Hrs

Course Objectives: The objective is to provide a basic understanding of fundamental mathematical concepts to students who have not studied mathematics at the +2 level.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will gain a solid understanding of foundational mathematical concepts including sets, relations, functions, trigonometric functions, complex numbers, sequences, series, permutations, combinations, and binomial theorem. They will be able to apply these concepts to solve problems in various mathematical contexts.
CO2	Learners will demonstrate proficiency in coordinate geometry, understanding properties of straight lines, and conic sections (circles, parabolas, ellipses, hyperbolas) as well as introductory knowledge of three-dimensional geometry. They will be able to analyze and solve problems related to these geometric figures.
CO3	Students will acquire skills in calculus, specifically focusing on limits, derivatives, continuity, differentiability, and integrals (both definite and indefinite). They will learn to apply calculus concepts to solve problems related to rates of change, tangents, normals, and area under curves.
CO4	By studying matrices, determinants, vectors, and vector operations (dot and cross products), students will enhance their problem-solving abilities in mathematical and engineering contexts. They will be able to model and solve problems using matrix algebra and vector calculus techniques.
CO5	Learners will be equipped with basic concepts in probability and statistics, enabling them to compute measures of central tendency, dispersion, and probability distributions. They will understand and apply addition and multiplication theorems of probability. Additionally, students will develop logical reasoning skills to evaluate mathematical statements and arguments.

COURSE CONTENTS

Module 1: Sets, relations and functions, trigonometric functions, complex numbers Principle of mathematical induction, Complex numbers and quadratic equations Linear inequalities Permutations and combinations Binomial theorem Sequences and series

Module 2: Coordinate Geometry: Straight lines and conic sections (like circles, parabolas, ellipses, hyperbolas) Introduction to three-dimensional geometry.

Module 3: Limits and derivatives Continuity and differentiability, Application of derivatives (like rate of change, tangents and normals), Integrals (including definite and indefinite integrals), Applications of integrals (like area under curves)

Module 4: Measures of central tendency, dispersion, and introduction to probability distribution
Probability: Basic concepts, addition and multiplication theorems of probability, Mathematical Reasoning: Mathematical statements and their truth values
Logical operations and their use in mathematics

Module X: Matrices and determinants, Differential equations; Order and degree, methods of solving first-order differential equations, Vectors and scalars, Dot and cross products of vectors.

References:
1. Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.
2. Advanced Engineering Mathematics Erwin Kreyszig, 10th edition
3. Advanced Engineering Mathematics, Michael D. Greenberg:
4. Higher Engineering Mathematics, B S Grewall, Khanna publishers

TEACHING LEARNING STRATEGIES
- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION
- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	30 marks
Continuous Evaluation	
Tests	12 Marks
Assignment	6 Marks
Seminar/Viva	12 Marks
Total	30 Marks

SEC

KU4SECMAT201 BASICS COURSE IN LATEX

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	SEC	200	KU4SECMAT201	3	45

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
3	1	30	30	60	2Hrs

Course Objectives: To understand the importance of Latex in scientific typing and importance of using online methods for typing. To understand the basic Latex typing techniques and get a practical knowledge of how to type a Project Report/ Research Paper.

COURSE CONTENTS

Module 1: Understanding the Importance of Latex and the Basics, what is Latex? The main features, online overleaf access, Title, sections, command and arguments, Labelling table of contents, font effects, coloured texts and font sizing (Relevant sections of the Text Book 1).

Module 2: Comments, spacing, special characters, Equations, Symbols and Project/Thesis Report Typing: Lists, tables and figures, Equations and symbols, Reference: Bibliography styles.

Module 3: Report typing: thesis/ project report, Document classes: article, book. beamer and slides.

Text Book: Guide to LATEX, fourth edition, Helmut Kopka, Patrick W.Daly **https://www.math.ucdavis.edu/~tracy/courses/math129/Guide_To_LaTeX. pdf**

Reference Books

1.Overleaf learning material https://www.overleaf.com/learn

2.https://mirror.niser.ac.in/ctan/macros/latex/contrib/beamer/doc/ beameruserguide.pdf

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	30 marks
Continuous Evaluation	
Practical Tests	12 Marks
Practical Assignments	12 Marks
Viva	6 Marks
Total	30 Marks