KANNUR UNIVERSITY

(Abstract)

M.Sc. Physics with Computational and Nano Science Specialization programme - Scheme, Syllabus, Model Question Paper and Pattern of Question Papers (first & Second semester only) under Choice Based Credit and Semester System (in Outcome Based Education System-OBE) in Affiliated Colleges -Implemented with effect from 2023 Admission - Approved -Orders issued.

ACADEMIC C SECTION

ACAD C/ACAD C5/20907/2023 Dated: 17.10.2023

Read:-1. U.O No. Acad C2/429/2017 Dated 08.09.2020.

2. U. O No. Acad C1/21246/2019 Dated 07.12.2020.

3. U.O. No. Acad/C1/21246/2019 Dated 16.02.2023.

4. U.O. No. Acad/C1/21246/2019 Dated 20.04.2023.

5. Minutes of the meeting of the CSMC & Conveners of Adhoc committee held on 15.06.2023

6. Orders of the Vice Chancellor in the file No. Acad C1/21246/2019 Dated 05.08.2023.

7. U.O. No. Acad/C1/21246/2019 Dated 09.08.2023.

8. The Minutes of the meeting of the Ad hoc Committee for Physics (PG) held on 20.09.2023.

9. Syllabus of M.Sc. Physics with Computational and Nano Science Specialization programme (First and Second Semester) submitted by the Convener, Ad hoc Committee for Physics (PG) vide e-mail dated 04.10.2023

ORDER

1. A Curriculum Syllabus Monitoring Committee comprising the members of Syndicate was constituted for the Syllabus revision of U G & PG Programmes in Affiliated Colleges, vide paper read (1) above and as per the recommendation of this Committee in its meeting held on 20.11.2020, constitute a sub Committee to prepare the Regulation for PG programmes in Affiliated Colleges vide paper read (2) above.

2. As the reconstitution of Board of Studies of the University is under the consideration of the Hon'ble Chancellor, and considering the exigency of the matter, Ad hoc Committees were constituted vide paper read (3) above and it has been modified vide paper read (4) above, to revise the Curriculum and Syllabus of PG Programmes in Affiliated Colleges w.e.f 2023- 24 academic year,.

3. The combined meeting of the Curriculum Syllabus Monitoring Committee & Conveners of Ad hoc committee held on 15.06.2023 at syndicate room discussed in detail the draft Regulation, prepared by the Curriculum Syllabus Monitoring Committee, for the PG programmes under Choice Based Credit and Semester System to be implemented in Affiliated Colleges w.e.f 2023 admission and proposed the different phases of Syllabus revision process such as subject wise workshop, vide the paper read (5) above.

4. The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System (In OBE- Out Come Based Education System) was approved by the Vice Chancellor on 05.08.2023 and implemented w.e.f 2023 Admission vide Paper read (7) above.

5. Subsequently, as per the paper read (8) above, the Ad hoc Committee for Physics (PG) finalized

the Scheme, Syllabus, Model Question Paper and Pattern of Question Papers of M.Sc. Physics with Computational and Nano Science Specialization programme (First and Second Semester) to be implemented with effect from 2023 Admission .

6. As per the paper read (9) above, the Convener, Ad hoc Committee for Physics (PG) submitted the finalized copy of Scheme, Syllabus, Model Question Paper and Pattern of Question Papers of M.Sc. Physics with Computational and Nano Science Specialization programme (First and Second Semester) for implementation with effect from 2023 Admission.

7. The Vice Chancellor after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1) Chapter III of Kannur University Act, 1996 and all other enabling provisions read together with ***accorded sanction to implement the Scheme, Syllabus, Model Question Paper and Pattern of Question Papers of*** **M.Sc. Physics with Computational and Nano Science Specialization programme (First and Second Semester)** ***under Choice Based Credit and Semester System (in OBE- Outcome Based Education System) in Affiliated Colleges under the University with effect from 2023 Admission, subject to report to the Academic Council.***

8. The Scheme, Syllabus, Model Question Papers and Pattern of Question Papers of M.Sc. Physics with Computational and Nano Science Specialization programme (First and Second Semester) under Choice Based Credit and Semester System (in OBE- Outcome Based Education System) in Affiliated Colleges under the University with effect from 2023 Admission is uploaded in the University website.

9. Orders are issued accordingly.

Sd/-

Narayanadas K

DEPUTY REGISTRAR (ACAD)

For REGISTRAR

To: 1. Principals of Affiliated Colleges offering M.Sc. Physics with Computational and Nano Science Specialization programme.
2. Convener, Curriculum Syllabus Monitoring Committee.
3. Convener, Ad hoc Committee for Physics (PG).

Copy To: 1. The Examination Branch (Through PA to CE)
2. PS to VC / PA to PVC / PA to R/PA to FO
3. DR / AR 1 (Acad) /Computer Programme
4. Web Manager (for uploading on the website).
5. EG 1/EX C1 (Exam), EP V
6. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

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

KV

KANNUR UNIVERSITY

(Abstract)

M.Sc. Physics with Computational and Nano Science specialization Programme- Syllabus Pattern of question paper and Model Question Paper-Third and Fourth semester only - Under Choice Based Credit and Semester System-(in OBE) in Affiliated Colleges-Implemented with effect from 2023 admissions- Orders issued

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ACADEMIC C SECTION

ACAD C/ACAD C5/20907/2023 Dated: 23.08.2024

Read:-1. U.O.No. ACAD C/ACAD C5/20907/2023 dtd: 17.10.2023

2. Minutes of the meeting of the BoS in Physics (PG) held on 27/05/2024

3. E-mail dtd 12/06/2024 from Chairperson BoS in Physics (PG)

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

ORDER

1. The Scheme, Syllabus, Pattern of Question Papers and Model question papers of First & Second Semester M.Sc. Physics with Computational and Nano Science specialization programme under CBCSS (In Outcome Based Education system) in Affiliated Colleges with effect from 2023 admission were approved and implemented vide paper read (1) above.

2.Subsequently, the Board of Studies in Physics (PG) vide paper read (2) discussed and approved the final Draft of the third and fourth Semester syllabuses of the M.Sc. Physics with Computational and Nano Science specialization programme in Affiliated Colleges.

3. Accordingly, the Chairperson, BoS (Board of Studies) in Physics (PG) submitted the final Draft of Syllabus, Pattern of Question papers and Model Question papers of the M.Sc. Physics with Computational and Nano Science specialization programme (Third and Fourth Semesters) in Affiliated Colleges for implementing w.e.f.2023 admission, vide paper read (3) above.

4. The Syllabuses concerned were placed before the Academic Council, for consideration.

5. XXVIII th Meeting of the Academic Council, held on 25/06/2024 considered the matter and approved the Syllabus, Pattern of Question Papers and Model Question papers of the M.Sc.Physics with Computational and Nano Science specialization programme (Third and Fourth Semesters) to be implemented in Affiliated Colleges w.e.f 2023 admission in principle and permitted to publish the same considering the urgency of the matter.

6. The Minutes of the Academic council was approved by the Vice Chancellor and published.

7.Therefore, the Syllabus, Pattern of Question Papers and Model Question Papers of the 3 rd& 4 th Semesters of the M.Sc.Physics with Computational and Nano Science specialization programme under Choice Based Credit and Semester System (in Outcome Based Education System) applicable in Affiliated Colleges under the University with effect from 2023 Admission are appended with this U.O and uploaded in the University website (www.kannuruniversity.ac.in).

Orders are issued accordingly.

Sd/-

ANIL CHANDRAN R
DEPUTY REGISTRAR (ACADEMIC)
For REGISTRAR

To: The Principals of Affiliated Colleges Offering M.Sc.Physics with Computational and Nanoscience specialization programme

Copy To: 1. The Examination branch (Through PA to CE)

2. PS to VC/PA to R/ Chairperson, BoS in Physics (PG)
3. DR/AR II (Acad) /Computer Programmer
4.IT Cell (for uploading on the website)
5. EG-1/EX C1 / AR-I/AR-II (Exam Branch)
6. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

KV

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

KANNUR UNIVERSITY
കണ്ണൂർ സർവ്വകലാശാല

Re-accredited by NAAC with 'B++' Grade

CURRICULUM & SYLLABUS

For Choice Based Credit Semester System

With Outcome Based Education

M.Sc. PHYSICS

with

Computational & Nano Science specialization Programme

(KUCBCSS - PG - 2023)

In Affiliated Colleges

With effect from 2023 Admission Onwards

www.kannuruniversity.com

Content

Preface

We are delighted to present the revised curriculum and syllabus for the M.Sc. Physics with Computational and Nano Science specialization Programme of affiliated colleges of Kannur University, which will be effective from the 2023 academic year onwards. This comprehensive curriculum is designed to provide students with a holistic and contemporary education in Physics, fostering a strong foundation in theoretical concepts, practical skills, and research-oriented thinking.

The revised M.Sc. Physics with Computational and Nano Science specialization Programme embraces a Choice Based Credit Semester System (CBCSS) with Outcome Based Education (OBE) at its core. This approach ensures that students have the flexibility to customize their learning journey while attaining specific learning outcomes, empowering students to shape the academic path according to their interests and career aspirations. The curriculum consists of 80 credits, distributed across various core courses, elective courses, and multidisciplinary open electives. By successfully completing the Programme, students will achieve a total of 1500 marks, reflecting the rigor and depth of knowledge we aim to impart.

The core courses encompass a diverse range of topics, thoroughly covering the fundamental principles of Physics. Additionally, two elective courses and one multidisciplinary open elective course provide students with the opportunity to explore specialized areas of interest beyond the core curriculum, making students' learning experience both enriched and personalized. We place special emphasis on Computational Physics and Nano Science, recognizing the growing significance of these two areas in advancing scientific research. By integrating computational techniques into practical sessions, students will develop proficiency in employing simulations and data analysis, preparing students for contemporary challenges in the field. Being a leading research area of today, Nano Sciences also find a significant role in this syllabus. The physics and applications of nano sciences will be taught under various courses in this programme. Two elective courses being offered in this programme will be chosen from two bunches, one each from Computational and Nano science.

We strongly believe in the value of experiential learning and have incorporated internship/project and institutional-industrial visits into the curriculum. These components are designed to bridge the gap between theoretical knowledge and practical application, allowing students to gain real-world exposure and hands-on experience. The emphasis on experiential learning aligns with our commitment to producing well-rounded and competent professionals in the field of Physics. To enable students to delve deeper into research and contribute to the scientific community, the final semester devotes ample time to project work. This is a crucial phase where students can apply the knowledge and skills acquired throughout the Programme to conduct independent research and make meaningful contributions to the field of Physics.

The successful revision of this curriculum would not have been possible without the collective efforts and inputs from the Ad Hoc-committee members, Resource Persons and the unwavering support of all Physics faculty members from the affiliated colleges. Their dedication and expertise have played an instrumental role in shaping a curriculum that is relevant, up-to-date, and in line with global academic standards.

As students embark on this transformative academic journey, we encourage students to approach studies with enthusiasm, curiosity, and a thirst for knowledge. We believe that the revised M.Sc. Physics with Computational and Nano Science specialization Programme will equip students with the essential skills and expertise to excel in the field of Physics and make meaningful contributions to society and the scientific community.

We wish students a fulfilling and rewarding experience throughout their academic pursuit at colleges affiliated to Kannur University.

Prof. (Dr.) N K Deepak,
Chairman,
PG Board of Studies in Physics
Kannur University

Vision and Mission of Kannur University

Vision:

To establish a teaching, residential and affiliating University and to provide equitable and just access to quality higher education involving the generation, dissemination and a critical application of knowledge with special focus on the development of higher education in Kasargod and Kannur Revenue Districts and the Mananthavady Taluk of Wayanad Revenue District.

Mission:

- ❖ To produce and disseminate new knowledge and to find novel avenues for application of such knowledge.
- ❖ To adopt critical pedagogic practices which uphold scientific temper, the uncompromised spirit of enquiry and the right to dissent.
- ❖ To uphold democratic, multicultural, secular, environmental and gender sensitive values as the foundational principles of higher education and to cater to the modern notions of equity, social justice and merit in all educational endeavours.
- ❖ To affiliate colleges and other institutions of higher learning and to monitor academic, ethical, administrative and infrastructural standards in such institutions.
- ❖ To build stronger community networks based on the values and principles of higher education and to ensure the region's intellectual integration with national vision and international standards.
- ❖ To associate with the local self-governing bodies and other statutory as well as non-governmental organizations for continuing education and also for building public awareness on important social, cultural and other policy issues.

Programme Outcomes (POs)

The objectives achieved at the end of any specialization or discipline of a Post-Graduate Programme of Kannur University:

PO-1 Advanced Knowledge and Skills: Postgraduate courses aim to provide students with in-depth knowledge and advanced skills related to their chosen field. The best outcome would be to acquire a comprehensive understanding of the subject matter and develop specialized expertise.

PO-2 Research and Analytical Abilities: Postgraduate Programmes often emphasize research and analytical thinking. The ability to conduct independent research, analyse complex problems, and propose innovative solutions is highly valued.

PO-3 Critical Thinking and Problem-Solving Skills: Developing critical thinking skills is crucial for postgraduate students. Being able to evaluate information critically, identify patterns, and solve problems creatively are important outcomes of these Programmes.

PO-4 Effective Communication Skills: Strong communication skills, both written and verbal, are essential in various professional settings. Postgraduate Programmes should focus on enhancing communication abilities to effectively convey ideas, present research findings, and engage in academic discussions.

PO-5 Ethical and Professional Standards: Graduates should uphold ethical and professional standards relevant to their field. Understanding and adhering to professional ethics and practices are important outcomes of postgraduate education.

PO-6 Career Readiness: Postgraduate Programmes should equip students with the necessary skills and knowledge to succeed in their chosen careers. This includes practical skills, industry-specific knowledge, and an understanding of the job market and its requirements.

PO-7 Networking and Collaboration: Building a professional network and collaborating with peers and experts in the field are valuable outcomes. These connections can lead to opportunities for research collaborations, internships, and employment prospects.

PO-8 Lifelong Learning: Postgraduate education should instill a passion for lifelong learning. The ability to adapt to new developments in the field, pursue further education, and stay updated with emerging trends is a desirable outcome.

Programme Specific Outcomes (PSOs)

The four-semester M.Sc. Physics with Computational and Nano Science specialization Programme aims to provide students with a comprehensive understanding of various theoretical and experimental aspects of physics. The Programme's specific objectives are designed to equip students with essential knowledge, skills, and experiences to excel in their chosen field. The Programme's specific objectives:

1. **Core Courses:** The core courses in the M.Sc. Physics with Computational and Nano Science specialization Programme are carefully curated to ensure that students acquire a solid foundation in classical and modern physics. The specific objectives of core courses include:

   PSO-1: Understanding fundamental concepts and principles in classical mechanics, electrodynamics, quantum mechanics, mathematical physics and statistical mechanics.

   PSO-2: Developing proficiency in solving complex physics problems using mathematical techniques and numerical methods.

   PSO-3: Gaining insights into cutting-edge research and recent advancements in various fields of physics.

2. **Elective Courses:** The Programme offers elective courses that allow students to specialize in specific areas of interest within physics. The specific objectives of elective courses include:

   PSO-4: Allowing students to explore advanced topics in computational and nano sciences.

   PSO-5: Encouraging critical thinking and analytical skills in solving specialized physics problems.

   PSO-6: Providing opportunities for students to develop expertise in their chosen fields and prepare them for further research or industry.

3. **Multidisciplinary Open Elective Courses:** These courses are designed to foster interdisciplinary thinking and encourage students to explore areas beyond physics. The specific objectives of multidisciplinary open elective courses include:

   PSO-7: Promoting a broader perspective and understanding of how physics interfaces with other scientific and non-scientific disciplines.

   PSO-8: Encouraging creativity and innovation through the application of physics concepts to real-world challenges in various domains.

   PSO-9: Developing communication skills to effectively collaborate with professionals from different backgrounds.

4. **Internship/Research Project:** The internship or project component of the Programme aims to provide students with hands-on experience in applying theoretical knowledge to practical situations. The specific objectives of internships/projects include:

   PSO-10: Offering opportunities to work on real-world problems in academia, research institutions, or industry settings.

PSO-11: Enhancing problem-solving and research skills by conducting independent investigations.

c. Cultivating teamwork, project management, and presentation skills.

5 **Institutional/Industrial Visits:** The institutional and industrial visits are crucial for exposing students to the actual working environment of research institutions and industries. The specific objectives of these visits include:

PSO-12: Providing insights into the application of physics principles in real-life scenarios.

PSO-13: Facilitating interaction with professionals and researchers to gain practical knowledge and career insights.

PSO-14: Fostering networking opportunities for potential future collaborations or job prospects.

6 **Experiential Learning and Computational Physics:** By incorporating experiential learning and computational physics as integral parts of the practical and project components, the specific objectives are:

PSO-15: Enabling students to gain hands-on experience in conducting experiments and simulations to reinforce theoretical concepts.

PSO-16: Developing proficiency in using computational tools and numerical methods for modelling and analysing complex physical systems.

PSO-17: Enhancing problem-solving skills and fostering a research-oriented mindset.

Overall, the M.Sc. Physics with Computational and Nano Science specialization Programme's specific objectives aim to produce well-rounded graduates with a deep understanding of physics principles, strong analytical and computational skills, and the ability to apply their knowledge to real-world challenges in academia, research, or industry settings.

M.Sc. Physics with Computational and Nano Science specialization
Programme Specific Regulations

In addition to these specific regulations, all students must adhere to the university's general PG Programme regulations. In case of any conflict between the M.Sc. Physics with Computational and Nano Science specialization Programme's specific regulations, the general regulations will take precedence and be followed. Stakeholders are required to comply with any updates or modifications made to the regulations by the university from time to time.

1 The name of the Programme is **M.Sc. Physics with Computational and Nano Science specialization.**

2 Eligibility for admission will be as per the rules laid down by the University from time to time.

3 The curriculum for the Programme follows a choice-based credit semester system with Outcome Based Education and consists of four semesters.

4 The medium of instruction for the Programme is English.

5 The minimum duration for completion of the M.Sc. Physics with Computational and Nano Science specialization Programme is two years and the maximum period for completion is 4 years.

6 The students admitted in the M.Sc. Programme shall be required to attend at least 75% of the total number of classes held during each semester. The students having less than the prescribed percentage of attendance shall not be allowed to appear for the University examination, if not eligible for condonation as per the general regulations.

7 **Structure of the Programme**

The Programme of instruction will consist of:

1. Core courses include Theory courses, Practical courses, Comprehensive Viva-voce, Seminar, Institutional/ Industrial visit and internship/ Project work (compulsory).
2. Elective courses (elective)
    - Two elective courses must be selected from the group of courses given, one from Elective-I (set of five courses) and one from Elective-II (set of five courses).
3. Multidisciplinary Open Elective Courses (departmental/other departmental) (elective)
    - One elective course must be selected from the group of courses given.

- **Practical courses**

The curriculum includes three distinct practical courses: Basic Physics Laboratory, Electronics Laboratory and Advanced & Computational Physics Laboratory.

- The Basic Physics Laboratory and Electronics Laboratory courses are integral part of this Programme. This course is designed to provide students with hands-on experience in conducting experiments, utilizing modern equipment, and understanding the principles of physics and electronics in practical applications.
- The Advanced & Computational Physics Laboratory course is an essential component in this Programme. It focuses on providing hands-on experience in using computational tools and techniques to solve complex problems, simulate physical phenomena, and design electronic devices. This practical course aims to bridge the gap between theoretical knowledge and real-world applications by immersing students in practical simulations and projects.

- **Comprehensive viva voce**

The comprehensive viva voce is an essential assessment included in the Programme to evaluate the student's grasp of the subject matter and their ability to apply their knowledge as defined in the course outcomes. It also provides an opportunity for the student to engage in academic discussions and receive valuable feedback from experts in the field.

- **Institutional/Industrial visit**

Incorporating institutional or industrial visits in the Programme brings immense value to the students, making their learning journey more enriching and preparing them for successful careers in physics-related fields.

- **Research Methodology course**

In the Research Methodology course, Part A is taught, and Part B involves self-learning. As a part of Part B, students are required to undertake a MOOC course on Research Methodology.

  - **MOOC course**:
    - ❖ The Department can offer students the freedom to select online courses from a pre-approved list. These courses, available on reputable platforms such as UGC-SWAYAM, Coursera, edX, NPTEL, etc., are chosen based on their duration and content significance. The list of approved courses will be communicated to students at the beginning of the first phase of the first semester. Students can only choose courses from this pre-approved set.
    - ❖ Throughout their M.Sc. Physics with Computational and Nano Science specialization Programme, students have the flexibility to register for and complete the chosen MOOC course at their convenience. However, completion must occur before the final phase of the fourth semester.
    - ❖ To be considered for continuous evaluation, students are required to present a valid document indicating successful course completion, along with marks or grades. The Department will have to review the submitted documents to ensure their validity and acceptability for assessment purposes.

- **Internship/Research Project**
  - The project is a major component of the Programme. Every student is required to undertake a research project under the guidance of a faculty member from their own department or, with the approval of the department, from other prestigious national or international institutions and submit a thesis at the end of the fourth semester [Preferable institutions are like, CUSAT, Physics research laboratory, institute for Plasma Research, BARC, IISc Bangalore, IIT's, IISERs, Central Universities, CSIR laboratories, NITs, TIFR, Regional Research Laboratory, Indian Statistical Institute, Saha Institute of Nuclear Physics, Raman Research Institute, IIA, inter university centres like IUCAA, NPOL, NPL, ISRO, DRDO, IIEST, IIST, reputed industrial organizations, etc and any other equivalent

institution. Also, students have the freedom to select any college or institution that provides research facilities and faculty expertise.]

- Departments can actively promote internships that can eventually lead to research project work.

8 Credit and total marks

The students must earn a total of 80 credits to be eligible for the degree. Credits will be assigned to the courses based on the following general pattern:

i) One credit for each Lecture/taught hour
ii) One credit for each Practical/Internship & Project/Tutorial session of two hours
iii) One credit for the Seminar hour
iv) One credit for the Comprehensive Viva-voce
v) One credit for the Institutional/Industrial visit (25 hours)

The credits are distributed as follows:

- Core courses: 68 credits
- Elective courses: 8 credits
- Multidisciplinary Open elective course: 4 credits

The total marks for the Programme is 1500.

9 Grading System

The Programme follows a Seven-point indirect relative grading system. The assessment of a student's performance in each course (both Continuous Evaluation and End-Semester Examination) will be conducted using an Indirect grading system. This system assigns letter grades (A+, A, B, C, D, E, and F) to each course based on the marks obtained using the Mark system for individual questions. The Indirect grading system follows specific guidelines to determine the letter grade, grade point, and percentage of marks for each course in the semester as given in the table:

%of Marks (CE+ESE)	Grade	Interpretation	Range of grade points
90 and above	O	Outstanding	9-10
80 to below 90	A	Excellent	8-8.9
70 below 80	B	Verygood	7-7.9
60 to below 70	C	Good	6-6.9
50 below 60	D	Satisfactory	5-5.9
40 to below 50	E	Pass	4-4.9
Below40	F	Failure	0-3.9

Each letter grade is assigned a ‘Grade point’ (GP) which is a point obtained using the formula:

Grade Point = (Total marks awarded / Total Maximum marks) x 10

Credit point (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course:

CP = GP x C

To successfully complete a course, a minimum grade point of 4 is required. To pass a course, a candidate must secure at least 40% aggregate marks (marks of both CE & ESE put together) with at least 40% in the End Semester Evaluation (ESE). There is no pass minimum requirement for Continuous Evaluation marks. The letter grade E corresponds to a grade point of 4, and it is the minimum grade required for course completion. Attendance for both Continuous Evaluation (CE) and End Semester Evaluation (ESE) is mandatory, and no grade will be awarded if a candidate is absent for either or both evaluations.

SGPA determines the overall performance of a student at the end of a semester. For the successful completion of a semester, a student should pass all courses in that semester. However, a student is permitted to move to the next semester irrespective of SGPA obtained. SGPA shall be rounded off to three decimal places. The Semester Grade Point Average (SGPA) for a student is calculated using the following formula:

SGPA = Sum of the Credit Points of all courses in a semester/Total Credits in that semester

The Cumulative Grade Point Average (CGPA) of the student determines the overall academic level of the student in each stage of the Programme. CGPA shall be rounded off to three decimal places. CGPA can be calculated by the following formula:

CGPA = Sum of Credit Points of all completed semesters/Total Credits acquired

At the end of the Programme, the overall performance of a candidate is indicated by the Overall Grade Point Average (OGPA). The OGPA of a student determines the overall academic level of the student in a Programme and is the criterion for classification and ranking the students. OGPA shall be rounded off to three decimal places. OGPA can be calculated by the following formula:

OGPA = Sum of Credit Points obtained in all semesters of the Programme/Total Credits (80)

An overall letter grade for OGPA for the entire Programme shall be awarded to a student after completing the entire Programme successfully. Overall letter grade based on OGPA and conversion of Grades into classification is given below:

Grade range OGPA	Overall Letter Grade	Classification
9 – 10	A+	First class with Distinction
8 - 8.999	A	

7 - 7.999	B	First class
6 - 6.999	C	
5 - 5.999	D	Second class
4 – 4.999	E	Pass
Below 4	F	Fail

The Percentage of marks based on OGPA is calculated by multiplying them by 10.

Percentage in two decimal places = [OGPA in three decimal places] x 10%

A student who fails to secure a minimum mark for a pass in a course is permitted to write the examination along with the subsequent batch.

10 Other Important Norms

- A candidate securing E grade with 40% of aggregate marks and 40% separately for each course shall be declared to have passed in that course.
- Those who secure not less than 40 % marks (marks of both ESE and CE put together) for all the courses of a semester shall be declared to have successfully completed the semester.
- The marks obtained by the candidates for CE in the first appearance shall be retained (irrespective of pass or fail)
- The candidates who fail in theory course shall reappear for theory course only, and the marks secured by them in practical course, if passed in practical, will be retained.
- A candidate who fails to secure a minimum for a pass in a course will be permitted to appear alongside the examinations conducted for the subsequent admission.
- For the successful completion of a semester, a candidate should pass all courses and secure a minimum SGPA of 4.
- A student is permitted to move to the next semester irrespective of the SGPA. A student will have the opportunity to enhance the results obtained in the ESE of any semester. This can be accomplished by reappearing for the ESE of any course from the respective semester, alongside the examinations conducted for the subsequent admission.
- If the candidate fails to appear for the improvement examination after registration, or if there is no change or improvement in the marks despite availing the improvement chance, the marks obtained in the first appearance shall be retained.
- There will be no opportunity for improving the marks obtained in internal assessment.
- A student can opt for improvement of a particular semester only once. The improvement chance can be availed in the succeeding year along with the subsequent batch.
- No supplementary examinations will be conducted.

11 Standard Operating Procedures for the conduct of Research Project

- A teacher from a department must be designated as Project Coordinator to coordinate the project related activities.

- All teachers are required to serve as internal supervisors for the research work, and the workload should be evenly distributed among the department's faculty.
- HoDs must ensure that each student receives adequate support and guidance throughout their research projects, promoting a fair and balanced approach to supervision within the department.
- Equal distribution of students should be maintained per faculty member as far as possible, and the allotment may be done during the last phase of second semester.
- The Conference presentation/Conference or journal publication related to the project work will be given significant weightage in the assessment of marks.
- Colleges offering M.Sc. Physics with Computational & Nano Science specialization Programmes have to organize conferences to foster research at the individual or cluster level at the last phase of fourth semester every year. This initiative provides students with ample opportunities to present extracts of their research projects as papers during these conferences. It allows students to showcase their work, gain valuable experience in presenting research findings, and interact with fellow researchers and experts in the field. These conferences play a vital role in enhancing the research culture within the institution and contribute to the overall academic and professional growth of the students.
- If a student wishes to undertake their project in an external institution, they are required to identify an external research supervisor affiliated with a nationally/internationally reputed institution. The student must then obtain a consent letter/email from the external supervisor and submit it to the Department for consideration. Upon approval from the Department, the student will be permitted to proceed with the project under the guidance of the chosen external supervisor.
- During the project's duration, the student will be supervised by an internal supervisor, who will regularly monitor the student's progress.
- For continuous evaluation of the project, the responsibility lies with the supervisor. In cases where the project is conducted outside the department, the evaluation can be conducted solely by the external supervisor or jointly by both the internal and external supervisors.

12 Continuous and End Semester Evaluation

The revised Bloom's Taxonomy is a valuable framework that can be utilized in the Continuous and End Semester Evaluation processes to assess learning outcomes effectively. It provides a structured and hierarchical approach to categorizing cognitive skills, making it easier to evaluate the depth and complexity of learning. The six levels of cognitive learning are remembering, understanding, applying, analysing, evaluating, and creating.

- **Remember:** This level involves recalling or recognizing facts, concepts, or information.
    - Appropriate learning outcome verbs for this level include: *cite,* define, describe, identify, label, list, match, name, outline, quote, *recall, report, reproduce, retrieve, show, state, tabulate, and tell*.
- **Understand:** At this level, learners demonstrate comprehension and grasp the meaning of the information they have learned.

    - Appropriate learning outcome verbs for this level include: abstract, arrange, articulate, associate, categorize, clarify, classify, compare, compute, conclude, contrast, defend, diagram, differentiate, discuss, distinguish, estimate, exemplify, explain, extend, extrapolate, generalize, give examples of, illustrate, infer, interpolate, interpret, match, outline, paraphrase, predict, rearrange, reorder, rephrase, represent, restate, summarize, transform, and translate.

- **Apply**: Learners use their knowledge and understanding to solve problems or apply concepts in new situations.
    - Appropriate learning outcome verb for this level include: apply, calculate, carry out, classify, complete, compute, demonstrate, dramatize, employ, examine, execute, experiment, generalize, illustrate, implement, infer, interpret, manipulate, modify, operate, organize, outline, predict, solve, transfer, translate, and use.
- **Analyse**: This level involves breaking down information into its constituent parts and understanding the relationships between them.
    - Appropriate learning outcome verbs for this level include: analyse, arrange, break down, categorize, classify, compare, connect, contrast, deconstruct, detect, diagram, differentiate, discriminate, distinguish, divide, explain, identify, integrate, inventory, order, organize, relate, separate, and structure.
- **Evaluate**: Learners critically assess information, make judgments, and present opinions based on criteria and evidence.
    - Appropriate learning outcome verbs for this level include: appraise, apprise, argue, assess, compare, conclude, consider, contrast, convince, criticize, critique, decide, determine, discriminate, evaluate, grade, judge, justify, measure, rank, rate, recommend, review, score, select, standardize, support, test, and validate.
- **Create**: At the highest level, learners demonstrate the ability to generate new ideas, products, or interpretations based on their understanding and synthesis of knowledge.
    - Appropriate learning outcome verbs for this level include: arrange, assemble, build, collect, combine, compile, compose, constitute, construct, create, design, develop, devise, formulate, generate, hypothesize, integrate, invent, make, manage, modify, organize, perform, plan, prepare, produce, propose, rearrange, reconstruct, reorganize, revise, rewrite, specify, synthesize, and write.

13 Continuous Evaluation (CE)

- Continuous evaluation typically involves assessing students' progress throughout the academic term.
- The minimum duration of the component ‘Test” in continuous evaluation is one hour for all courses.

- The questions for CE (Continuous Evaluation) should be designed using the Revised Bloom's Taxonomy framework.
- The continuous evaluation (CE) component of the Programme will account for 20% of the total marks for each course except for the Internship/Project and Research methodology course.
- In the Research Methodology and Experimental Techniques course, Part A is taught, and Part B involves self-learning. As a part of Part B, students are required to undertake a MOOC course on Research Methodology and submit the certificate from the competent authority to the department. Students have the flexibility to complete the MOOC course at any time during their M.Sc. Programme but before the conclusion of the continuous evaluation of the Research Methodology course.
- Appearance for CE is compulsory and no marks shall be awarded to a candidate, if absent from evaluation.
- Ensure transparency in the assessment process by keeping students informed about the evaluation criteria and assessment schedule. Communicate any changes or updates to the assessment process promptly.
- Continuous assessment should be completed two weeks before the last working day of each semester.
- Continuous Assessment marks should be published on the department notice board
- **Consolidated and individual registers for recording continuous assessment marks must be maintained in the department**.
  - Teachers should update the register regularly as assessments are conducted and valued.
  - Student Signatures: After each assessment, students should review their marks and sign the register to confirm that they agree with the recorded scores.
  - Teacher Signatures: Teachers should sign the register next to the marks they have entered, indicating their responsibility for the assessment.
  - HoD Approval: The Head of the Department (HoD) plays a supervisory role in the assessment process. The HoD should review the register periodically, ensuring that the assessments are conducted fairly and that the marks are accurately recorded.
  - Dispute Resolution: In case of any discrepancies or disagreements regarding the recorded marks, there should be a clear procedure for dispute resolution. This may involve meetings between students, teachers, and the HoD to resolve any issues as per the general regulation.

14 End Semester Evaluation (ESE)

- The duration of the End Semester Examination is 3 hours for the theory courses and 5 hours for practical courses.
- The questions for ESE (End-Semester Examination) should be designed using the Revised Bloom's Taxonomy framework.

- The end semester evaluation (ESE) component of the Programme will account for the remaining 80% of the total marks for core, elective and open elective courses.
- End Semester Evaluation of the theory courses will be conducted at the end of each semester by the University.
- Examination for the First and Second Practical courses will be conducted together at the end of Second semester. Practical Examination for the Third semester will be conducted at the end of the semester itself.
- There shall be improvement chances for the marks obtained in the core/elective/open elective courses only. No improvement chances will be given for any other courses outlined in the Programme.
- Practical examinations and comprehensive viva voce and evaluation of the institutional/Industrial report have to be conducted by a minimum 2-member panel consisting of the internal supervisor and external faculty members nominated by the Chairperson, Board of Examinations of Kannur University.

15 External examiners assigned to conduct the comprehensive viva voce, practical or project evaluations must not be selected for consecutive years in a college. They become eligible for reappointment after a gap of three years.

16 There shall be no improvement chance for the marks obtained in the project report.

17 Institutional /Industrial visit is introduced for experiential learning.

18 Information about the evaluation process, grading schemes, and examination formats are outlined in the general regulations.

19 Project evaluation CE & ESE

- Minimum two seminar presentations in online/offline or blended mode must be conducted to evaluate the progress of the project and students must submit the report (both soft and hard copy) at least 5 days before the presentation to the Project coordinator.
- Students must submit a thesis based on the research project and they must defend the thesis in an oral examination. The thesis shall be prepared according to the guidelines (Annexure I).
- No marks shall be awarded to a student, if fails to submit the Thesis for external evaluation.
- A pre-submission presentation must be conducted in online/offline or blended mode before the final submission of the thesis to receive feedback from experts in the field and must be evaluated by a 3-member panel consisting of the internal supervisor, Project Coordinator and Head of the Department.
- Plagiarism is strictly prohibited in the thesis. Students are expected to produce original work and properly acknowledge any sources they have referenced or cited in their thesis.

- Strictly enforces a zero-tolerance policy for plagiarism in core areas, while a maximum of 20% plagiarism is permissible in non-core areas.
- Plagiarism check shall exclude the following:

    - All quoted work with the necessary permission/attribution.
    - References, Bibliography, table of content, preface and acknowledgments.
    - The generic terms, laws, standard symbols and equations.

- The final thesis must undergo a plagiarism check using a designated system of the University or a reputed institution, and the resulting plagiarism certificate must be included as part of the submission by the student.
- On the Institutions website, Departments must create Masters' Repository of thesis/paper/publication etc.
- The Conference presentation or journal publication related to the project work will hold substantial significance in the final evaluation of marks during the external project assessment. This importance will be granted on the condition that the submission includes a certificate from the competent authority verifying the authenticity of the presentation or publication.
- An end semester evaluation based on a viva voce examination shall be conducted at the end of the fourth semester by a 3-member panel consisting of the internal supervisor and other faculty members nominated by the Chairperson, Board of Examinations of PG Physics of Kannur University.
- Students must submit the final thesis (both soft and hard copy) at least 20 days before the external assessment to the Project coordinator duly signed by the internal supervisor (and the external supervisor, if any). The Project coordinator has to submit the same to the external evaluators for peer review before the scheduled date of viva voce.
- In order to successfully pass the Project course, a student must attain a minimum aggregate of 40% or higher, along with a score of at least 40% in the external evaluation.
- If a student fails to obtain a minimum of 40% marks, they will have the opportunity to redo the Project course and resubmit the report through the parent department before subsequent examinations.

Components of CE and ESE

1. Theory courses excluding Research Methodology course

Theory

Sl. No.	Components	% of internal Marks
1	Two test papers	50
2	Two assignments	25
3	Seminars/viva Voce	25

Theory: Methodology course		
Sl. No.	**Components**	**% of internal Marks**
1	One test paper	30
2	One assignment	30
3	MOOC course certificate	40

2. Practical courses

Practical		
No	**Components**	**% of internal marks**
1	Test papers	40
2	Laboratory skill	30
3	Laboratory Record/Observation	30

3. Seminar

Seminar topics should focus on associated and advanced subjects relevant to the core, elective, open elective courses, or allied courses. Topics covered within the syllabus should be avoided for seminar presentations. There will be only internal evaluation for the Seminar.

4 Institutional/Industrial visit

Assessing an institutional or industrial visit for experiential learning involves evaluating the students' understanding, learning experiences, and insights gained during the visit. The assessment may consist of several components, including a report, analysis, and viva voce examination.

Institutional/Industrial Visit			
Internal Viva voce (10 marks)		External Viva voce (20 marks)	
Components	% of internal Marks	Components	% of external marks
Report evaluation	40	Report evaluation	40
Viva Voce	40	Viva Voce	40
Experiential learning and skill development	20	Experiential learning and skill development	20
Total	**100**	**Total**	**100**

4.1 Notes for evaluation:

1 Report Evaluation:
- Content: Assess the content of the report to ensure it covers the key aspects of the visit, such as objectives, observations, interactions, and reflections.
- Structure: Evaluate the organization and coherence of the report, including the introduction, main body, and conclusion.
- Reflection: Look for evidence of critical thinking and reflection on the experiences and learning outcomes during the visit.
- Communication: Evaluate the clarity, conciseness, and effectiveness of the students' writing in conveying their experiences.

2 Analysis:
- Interpretation: Assess the students' ability to interpret the observations made during the visit and connect them to theoretical concepts or real-world applications.

- Depth of Analysis: Evaluate the depth of analysis in exploring the relevance and implications of the experiences to the academic curriculum or professional context.
- Problem-Solving: Look for evidence of problem-solving skills demonstrated by students in analysing challenges or issues encountered during the visit.

3 Viva Voce Examination:
- Knowledge: Test the students' knowledge and understanding of the concepts related to the industrial or institutional visit.
- Application: Evaluate their ability to apply the knowledge gained during the visit to answer questions and solve problems posed during the viva voce.
- Communication: Assess how effectively students communicate their experiences, insights, and responses during the viva voce session.

4 Experiential Learning and Skill Development:
- Identify the specific experiential learning opportunities provided during the visit and assess how they contribute to the students' overall skill development.
- Analyse the relevance of the visit to the students' academic and career goals, and its potential impact on their future endeavours.

5 Teamwork and Collaboration:
- If the visit involves group activities, evaluate the students' ability to collaborate effectively, demonstrate teamwork, and support each other during the visit.

6 Overall Assessment:
- Consider the overall quality of the experiential learning report, analysis, and viva voce performance to provide a comprehensive evaluation of each student's experience.

Ultimately, the assessment should focus on recognizing the value of experiential learning, encouraging students' active engagement in their learning process, and identifying areas of improvement to enhance future visit experiences.

5. Comprehensive Viva voce

Conducting a comprehensive viva voce involves evaluating a student's knowledge, understanding, and critical thinking skills on a wide range of topics related to their course or academic field. Some steps to effectively conduct a comprehensive viva voce:

1 Preparation:
- Review the student's academic records, including their coursework, projects, assignments, and other relevant materials, to understand their overall performance and areas of specialization.

- Identify the key topics and concepts that the viva voce will cover, ensuring a comprehensive representation of the student's knowledge.

2 Create a Structured Format:
- Organize the viva voce into different sections or themes to cover various aspects of the curriculum comprehensively.
- Consider including sections that cover theoretical knowledge, practical applications, problem-solving exercises, and the student's opinions or research interests.

3 Clear Communication:
- Communicate the format and expectations of the viva voce to the student in advance, so they know what to prepare for and what to expect during the examination.

4 Ask Open-ended Questions:
- Frame questions in a way that encourages the student to provide detailed and thoughtful responses, demonstrating their depth of understanding and critical thinking abilities.

5 Encourage Explanation and Elaboration:
- Prompt the student to explain their answers and elaborate on their thought processes, allowing them to showcase their knowledge and reasoning skills.

6 Cover Diverse Topics:
- Ensure that the viva voce covers a wide range of topics within the subject area, testing the student's grasp of both fundamental concepts and advanced topics.

7 Create a Positive Environment:
- Establish a supportive and encouraging atmosphere during the viva voce to help the student feel more comfortable and confident in answering the questions.

8 Engage in Discussion:
- Encourage a back-and-forth discussion with the student, exploring their understanding of complex concepts and encouraging them to defend their viewpoints.

9 Provide Feedback and Guidance:
- Offer constructive feedback on the student's responses, pointing out strengths and areas for improvement. This can be an educational opportunity to enhance their knowledge further.

10 Assess Critical Thinking:
- Pose questions that assess the student's ability to think critically, analyze information, and apply knowledge to solve problems or address real-world scenarios.

11 Time Management:

- Manage the viva voce session efficiently to cover all the essential topics while allowing the student sufficient time to respond thoughtfully.

12 Maintain Professionalism:

- Conduct the viva voce with professionalism, fairness, and objectivity, ensuring that the assessment is unbiased and consistent for all students.

A comprehensive viva voce provides an excellent opportunity to gauge the depth and breadth of a student's knowledge and understanding of their academic subject, and it can be a valuable tool for both the student's learning and the overall assessment process.

6. Research Project

Research Project			
Internal Viva voce (40 marks)		External Viva voce (80 marks)	
Components	% of internal Marks	Components	% of external marks
Understanding	10	Research Content	15
Literature survey	10	Scientific Methodology	10
Experimental/Theoretical formulation	20	Presentation Skills Visual Aids	25
Performance	15	Originality and Creativity Data Analysis Results and Findings	25
Results and Findings Interpretation of results	25	Conference Presentation/Conference Publication/Journal Publication	10
Progress report 1 Progress report 2 Pre-submission Presentation	10	Adherence to Guidelines Certificate of Plagiarism Check	5
Thesis	10	Thesis	10
Total	100	Total	100

6.1. Notes for evaluation:

When valuing the M.Sc. Physics with Computational & Nano Science specialization research project, the assessment typically involves various components that evaluate the student's research, understanding, and presentation skills. The components for evaluating the research project may include:

1 Research Content: Assessing the depth and significance of the research conducted by the student, including the originality and relevance of the chosen topic.
2 Scientific Methodology: Evaluating the appropriateness and rigor of the scientific methods used in the research, such as experimental design, data collection, and analysis techniques.
3 Literature Review: Examining the student's understanding and incorporation of relevant literature and previous research on the chosen topic.
4 Problem Solving: Assessing the student's ability to identify and address scientific problems and challenges during the research process.
5 Data Analysis: Reviewing the accuracy and appropriateness of the data analysis methods employed by the student.
6 Results and Findings: Evaluating the clarity and significance of the research results and the student's ability to interpret and communicate their findings effectively.
7 Critical Thinking: Assessing the student's capacity for critical thinking, logical reasoning, and analytical skills in the context of the research.
8 Presentation Skills: Evaluating the student's oral and written communication skills in presenting their research, including clarity, coherence, and organization.
9 Visual Aids: Reviewing the use and effectiveness of visual aids, such as graphs, charts, and illustrations, in enhancing the presentation.
10 Conclusions and Recommendations: Examining the student's ability to draw appropriate conclusions and provide relevant recommendations based on their research findings.
11 Originality and Creativity: Assessing the level of originality and creativity demonstrated by the student in their research approach and problem-solving.
12 Adherence to Guidelines: Ensuring that the student's project adheres to the specified guidelines, formatting, and requirements set by the University.
13 Overall Quality: Providing an overall evaluation of the project's quality, organization, and contribution to the field of study.

Scheme and Credit Distribution

Semester	Course Code	Title	Marks			Credit	Hours/ Week
			Internal	External	Total		
I	MSPHN01C01	Classical Mechanics	15	60	75	4	4
	MSPHN01C02	Mathematical Physics I	15	60	75	4	4
	MSPHN01C03	Electrodynamics	15	60	75	4	4
	MSPHN01C04	Electronics	15	60	75	4	4
	MSPHN01C05	Laboratory I	Carried over to Semester II				4
	MSPHN01C06	Laboratory II	Carried over to Semester II				4
	MSPHN01C07	Seminar I	Carried over to Semester II				1
TOTAL			**60**	**240**	**300**	**16**	**25**

Semester	Course Code	Title	Marks			Credit	Hours/ Week
			Internal	External	Total		
II	MSPHN02C08	Quantum Mechanics I	15	60	75	4	4
	MSPHN02C09	Statistical Mechanics	15	60	75	4	4
	MSPHN02C10	Mathematical Physics II	15	60	75	4	4
	MSPHN02C11	Spectroscopy	15	60	75	4	4
	MSPHN02C05 & MSPHN01C05	Laboratory I	12	48	60	4	4
	MSPHN02C06 & MSPHN01C06	Laboratory II	12	48	60	4	4
	MSPHN02C07 & MSPHN01C07	Seminar I	10	-	10	1	1
	MSPHN02C12	Comprehensive Viva voce	5	15	20	1	
TOTAL			**99**	**351**	**450**	**26**	**25**

Semester	Course Code	Title	Marks			Credit	Hours/ Week
			Internal	External	Total		
III	MSPHN03C13	Quantum Mechanics II	15	60	75	4	4
	MSPHN03C14	Condensed Matter Physics	15	60	75	4	4
	MSPHN03C15	Nuclear & Particle Physics	15	60	75	4	4
	MSPHN03C16	Laboratory III	12	48	60	3	8
	MSPHN03O 01-05	Open Elective Course	15	60	75	4	4
	MSPHN03C17	Institutional/Industrial Visit	10	20	30	1	-
	MSPHN03C18	Seminar II	10	-	10	1	1
TOTAL			**92**	**308**	**400**	**21**	**25**

Semester	Course Code	Title	Marks			Credit	Hours/ Week
			Internal	External	Total		
IV	MSPHN04E 01-05	Elective Course I	15	60	75	4	4
	MSPHN04E 06-10	Elective Course II	15	60	75	4	4
	MSPHN04C19	Research Methodology & Experimental Techniques	10	30	40	1	2
	MSPHN04C20	Internship/ Project	40	80	120	7	14
	MSPHN04C21	Comprehensive Viva voce	10	30	40	1	1
TOTAL			**90**	**260**	**350**	**17**	**25**
GRAND TOTAL					**1500**	**80**	

Elective Courses

A. Elective - I

1 Computational Physics
2 Microprocessors and DSP
3 Quantum Optics and Computing
4 Computational Materials Sciences
5 Quantum Field Theory

B. Elective - II

1 Physics of Nano Systems
2 Nano Optics
3 Thin Films, Crystal Growth and Characterization
4 Materials Sciences
5 Biophysics and Bionanotechnology

Open Elective Courses (Multidisciplinary)

1 Machine Learning and Data Science
2 Radiation Physics
3 Environmental Physics and Earth Sciences
4 Physics in Disaster Management: Understanding and Mitigating Natural Hazards
5 Wonders of Quantum World

Practical Courses

19...1 Practical I : Basic Physics Laboratory
19...2 Practical II : Electronics laboratory
19...3 Practical III : Advanced and Computational Physics Laboratory

Question Pattern (60 marks)

<table>
<tr><th>Part</th><th colspan="2">Details of Questions</th><th>Marks</th><th>Level (Revised Bloom's Taxonomy)</th><th>Time to answer</th></tr>
<tr><td rowspan="3">A</td><td>No. of Questions in QP</td><td>6</td><td rowspan="3">15</td><td rowspan="3">1, 2
Remembering
Understanding</td><td rowspan="3">30 minutes</td></tr>
<tr><td>No. Questions to be answered</td><td>5</td></tr>
<tr><td>Marks for each question</td><td>3</td></tr>
<tr><td rowspan="3">B</td><td>No. of Questions in QP</td><td>5</td><td rowspan="3">18</td><td rowspan="3">6
Creating</td><td rowspan="3">60 minutes</td></tr>
<tr><td>No. Questions to be answered</td><td>3</td></tr>
<tr><td>Marks for each question</td><td>6</td></tr>
<tr><td rowspan="3">C</td><td>No. of Questions in QP</td><td>5</td><td rowspan="3">27</td><td rowspan="3">3, 4, 5
Applying
Analysing
Evaluating</td><td rowspan="3">90 minutes</td></tr>
<tr><td>No. Questions to be answered</td><td>3</td></tr>
<tr><td>Marks for each question</td><td>9</td></tr>
<tr><td colspan="3">Total Marks</td><td>60</td><td></td><td>180 minutes</td></tr>
<tr><td colspan="6">Module-wise distribution of marks</td></tr>
<tr><td colspan="2">Module</td><td>Module 1</td><td>Module 2</td><td>Module 3</td><td>Module 4</td></tr>
<tr><td colspan="2">Minimum marks</td><td>15</td><td>15</td><td>15</td><td>15</td></tr>
</table>

SYLLABUS

SEMESTER-I

MSPHN01C01 - Classical Mechanics

Contact hours -72 (54 Lectures + 18 Tutorials)

Course Objectives:

The primary objective of this course is to teach the students Classical Mechanics at a level more advanced than what they have learnt in their B.Sc. The course aims to introduce students to the Lagrangian, Hamiltonian and Hamilton-Jacobi formulations. Students will receive a strong grounding in these methods, paving the way for advanced topics in many other fields of physics such as quantum mechanics and statistical mechanics.

Module 1: (14 L + 6 T)

Lagrangian Formulation: Constraints, Principle of virtual work, D'Alembert's principle and Lagrange's equations, Simple applications of the Lagrangian formulation, Hamilton's principle, Some techniques of the calculus of variations, Derivation of Lagrange's equations from Hamilton's principle - Euler-Lagrange differential equations, Conservation theorems and symmetry properties (qualitative treatment only)-Cyclic coordinates.

The Central force problem-Reduction to the equivalent one-body problem, The equations of motion and first integrals, Classification of orbits, The Kepler problem. **(Sections 1.3, 1.4, 1.6, 2.1, 2.2, 2.3, 2.6, 3.1, 3.2, 3.3, 3.7 of Book for study)**

Tutorial 1: Problems to illustrate the applications of Lagrange's formulation (Simple pendulum, Atwood's machine, Compound pendulum, Spherical pendulum, Harmonic oscillator), Applications of variational principle (Shortest distance between two points in a plane, Minimum surface of revolution, The brachistochrone problem.)

Module 2: (14 L + 6 T)

Hamiltonian Formulation: The Hamiltonian function, Legendre transformations and the Hamilton's equations of motion-Phase space, Canonical transformations-Equations of canonical transformation, Examples of canonical transformations, The harmonic oscillator, Poisson brackets and other canonical invariants, Hamilton's equation in Poisson bracket form, Poisson's theorem, Infinitesimal canonical transformation, The angular momentum Poisson bracket relations. **(Sections 8.1, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7 of Book for study)**

Tutorial 2: Applications of Hamilton's equation and derivation of equations of motion- (Two dimensional isotropic harmonic oscillator, Charged particle in an electromagnetic field, Kepler problem), Checking whether a given transformation is canonical, Angular momentum Poisson brackets, Phase space diagram of Harmonic oscillator.

Module 3:(14 L + 2 T)

Hamilton-Jacobi Formulation: Hamilton-Jacobi equations-Hamilton's principal and characteristic functions, The one-dimensional harmonic oscillator problem as an example of the Hamilton-Jacobi method, The Hamilton-Jacobi equation for Hamilton's characteristic function, Action angle variables-linear harmonic oscillator. **(Sections 10.1, 10.2, 10.3, 10.6 of Book for study)**

Small Oscillations: Formulation of the problem-Stability analysis-Lagrange's equations of motion for small oscillations, The Eigenvalue equation, Frequencies of

free vibrations and normal coordinates, Free vibrations of a linear triatomic molecule. **(Sections 6.1, 6.2, 6.3, 6.4 of Book for study)**
Tutorial 3: Kepler problem using Hamilton-Jacobi method, Problems on coupled oscillators-determination of normal frequency.

Module 4: (12 L + 4 T)
Rigid Body Dynamics: The independent coordinates of a rigid body-Euler angles, Infinitesimal rotations, Rate of change of a vector, Centrifugal and Coriolis forces, The inertia tensor and the moment of inertia-The Eigenvalues of the inertia tensor and the Principal axis of transformation, The Euler's equation of motion, Torque free motion of a rigid body. **(Sections 4.1, 4.4, 4.8, 4.9, 4.10, 5.3, 5.4, 5.5, 5.6 of Book for study**)
Tutorial 4**:** Problems on Principal moments of inertia, Coriolis force etc.

Book for Study:

Herbert Goldstein, Charles P. Poole and John Safko: "Classical Mechanics" (3rd Edition, Pearson Education, 2011)

References:

1. T. Thornton and J B. Marion, Classical Dynamics of Particles and Systems, Cengage.
2. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, TMH.
3. N. C. Rana and P. S. Joag, Classical Mechanics, TMH.
4. G. Aruldhas, Classical Mechanics, PHI.
5. V. B. Bhatia, Classical Mechanics, Narosa Publishers.
6. Gupta, Kumar and Sharma, Classical Mechanics, Pragati Prakashan.
7. J.C. Upadhyaya, Classical Mechanics, Himalaya Publishing House.
8. A K Raychaudhuri, Classical Mechanics: A Course of Lectures, OUP.
9. Schaum's outline Series on "Theoretical Mechanics" by Murray R Spiegel
10. NPTEL Video Course-Classical Mechanics-From Newtonian to Lagrangian Formulation, Prof. Debmalya Banerjee.

Course Learning Outcomes:
Upon successful completion of this course, students will be able to:

- Deal with particle mechanics at an advanced level.
- Use the calculus of variations to characterize the function that extremizes a functional.
- Understand the concept of constraints, principle of least action and formulation of Lagrange's method and apply Lagrange's equation for simple dynamical systems.
- Understand Central force and its application in Kepler's problem.
- Formulate and solve problems in classical mechanics using the Lagrangian, Hamiltonian and Hamilton-Jacobi formulations.
- Apply the methods of classical mechanics to identify conserved quantities and normal modes.
- Analyze motion of rigid bodies in non-inertial frames of reference using Euler angles and Euler's equations.

MSPHN01C02- Mathematical Physics I

Contact Hours: 72 hrs (54 Lectures + 18 Tutorials)

Course Objective:

This course is designed to provide students with the fundamental mathematical and computational techniques necessary to comprehend and solve problems in physics.

Course Learning Outcomes:

- **CSO1 - Provide a solid foundation in linear algebra:** This includes a thorough understanding of vectors, matrices, linear transformations, eigenvalues, eigenvectors, and the concept of diagonalization. Students will also learn the basics of tensor analysis.
- **CSO2 - Understand infinite series and Fourier transforms:** Students will be exposed to the concepts of infinite and power series, along with their convergence properties. Furthermore, they will learn about the Fourier series and Fourier transforms, including their properties and applications in physics.
- **CSO3 - Master special functions and orthogonal polynomials:** The course aims to impart knowledge about special functions like Gamma and Beta functions, Legendre and Bessel functions, and the concept of orthogonal polynomials such as Hermite and Laguerre polynomials. Students will learn how these functions and polynomials are used to solve problems in physics.
- **CSO4 - Develop expertise in ordinary and partial differential equations (ODEs and PDEs):** Students will learn how to solve ODEs and PDEs, with a specific focus on systems of ODEs, the Laplace equation, and the wave equation. They will also gain an understanding of their applications in physics.
- **CSO5 - Apply mathematical methods to physical problems and promote computational skills:** The course aims to develop students' ability to use these mathematical methods to analyse and solve problems in physics. The tutorial sessions will particularly focus on practical applications, enhancing problem-solving skills. As part of the course, students will use computational tools to solve complex problems, enhancing their computational physics skills.

Module I: Linear Algebra and Matrices (14L + 4T)

Linear Algebra (Book 1, Chapters 7-8)

- **Matrices (3 Lectures + 1 Tutorial)**
  - Linear Independence - Rank, Vector Spaces.
  - Solutions of Linear Systems - Existence, Uniqueness
  - The inverse of a Matrix - Gauss–Jordan Elimination
  - Vector Spaces, Inner Product Spaces, Linear Transformations
  - Problems involving linear algebra [Tutorial]

- **Eigenvalues and Eigenvectors (4 Lectures + 1 Tutorial)**
    - Definition of eigenvalues and eigenvectors
    - Calculation of eigenvalues and eigenvectors
    - Applications of Eigenvalue Problems
    - Symmetric, Skew-Symmetric, and Orthogonal Matrices
    - Problems in eigenvalue decomposition [Tutorial]
- **Diagonalization of Matrices (2 Lectures + 1 Tutorial)**
    - The concept of diagonalization
    - Diagonalizability and similarity transformations
    - Procedures for diagonalizing matrices
    - Complex Matrices and Forms - Hermitian, Skew-Hermitian, and Unitary matrices
    - Problems involving diagonalisation of matrices [Tutorial]

Tensors(Book 2, Chapter 10)

- **Introduction to Tensor Analysis (5 Lectures + 1 Tutorial)**
    - Definition of tensors, tensor notations, summation convention, contraction,
    - Tensors and matrices, symmetric and antisymmetric tensors, quotient rule, change of basis, tensors of different order.
    - Kronecker delta and the Levi-Civita symbol. Vector identities. Dual tensors.
    - Pseudo vectors and pseudo tensors. Cross product.
    - Curvilinear coordinates - scale factors and basis vectors, vector operators, and non-Cartesian tensors. Contravariant and covariant vectors. Basis vectors. Metric tensor. Raising and lowering of indices.
    - Physical applications of tensors, moment of inertia tensor, electric polarisation. [Tutorial]

Module II: Series and Fourier Transforms (14L + 4T)

Infinite Series, Power Series (Book 2, Chapter 1)

- Sequences and Series (2 Lectures)
    - Definitions and notations - geometric series,
    - Convergent and divergent sequences and series
- Convergence Tests (2 Lectures + 1 Tutorial)
    - Preliminary test
    - Convergent tests - absolute convergence - the comparison test, the integral test, the ratio test, the special comparison test
    - Alternating series and Leibniz's rule
    - Problems involving series convergence tests [Tutorial]
- Power Series (2 Lectures + 1 Tutorial)
    - Definition and examples of power series
    - Convergence of power series
    - Interval and radius of convergence
    - Problems involving power series [Tutorial]

Fourier Series and Transforms (Book 1, Chapter 11)

- **Fourier Series** (4 Lectures + 1 Tutorial)
  - Introduction to the Fourier series
  - Conditions of convergence
  - Fourier series for even and odd functions
  - Half-range Fourier series
  - Sturm-Liouville problems – eigenvalues, eigenfunctions. Orthogonality.
  - Applications in physics: forced oscillations, vibrating string, solving PDEs (Tutorial)
- **Fourier Integrals** (4 Lectures + 1 Tutorial)
  - Fourier integral
  - Applications of Fourier Integrals
  - Fourier sine and cosine integrals
  - Fourier sine and cosine transforms
  - Inverse Fourier transforms
  - Convolution theorem
  - Power Spectrum (Physical Interpretation), Discrete and Fast Fourier Transforms (Tutorial)

Module III: Special Functions and Orthogonal Polynomials (12L + 6T)

(Book 2, Chapter 11)

- Gamma and Beta Functions (3 Lectures + 2 Tutorial)
  - The factorial function
  - Definition and properties of the Gamma function
  - The Gamma function of negative numbers
  - Definition and properties of the Beta function
  - Relationship between Gamma and Beta functions
  - Applications - the simple pendulum, Stirling's formula, Elliptic integrals (Tutorial)

(Book 2, Chapter 12)

- Legendre Polynomials (4 Lectures + 2 Tutorial)
  - Introduction to Legendre polynomials
  - Legendre's equation
  - Rodrigues' formula
  - Generating function for Legendre polynomials
  - Recursion relations
  - Orthogonality of Legendre polynomials
  - Normalization of Legendre polynomials
  - Associated Legendre polynomials
  - Applications in electrostatics, quantum mechanics (angular part of the wavefunction in spherical coordinates) - (Tutorial)
- Bessel Functions (3 Lectures + 1 Tutorial)
  - Introduction to Bessel functions
  - Solutions of Bessel's differential equation

- The second solution of Bessel's equation
- Graphs and zeros of Bessel functions
- Recursion relations
- Differential equations with Bessel function solutions.
- Orthogonality of Bessel functions
- Other kinds of Bessel functions - Neumann functions and Hankel functions, Spherical Bessel functions.
- Applications in wave propagation, heat conduction, and vibrations of circular membranes (Tutorial)

- Hermite and Laguerre Polynomials (2 Lectures + 1 Tutorial)
  - Introduction to Hermite polynomials
  - Generating function for Hermite polynomials
  - Orthogonality of Hermite polynomials
  - Introduction to Laguerre polynomials
  - Generating function for Laguerre polynomials
  - Orthogonality of Laguerre polynomials
  - Associated Laguerre polynomials
  - Applications in quantum mechanics (harmonic oscillator, wavefunctions of the hydrogen atom) [Tutorial]

Module IV: ODEs and PDEs (14L + 4T)

Systems of Ordinary Differential Equations (Book 1, Chapter 4)

- Systems of ODEs (4 Lectures + 2 Tutorial)
  - Basics of matrices and vectors
  - Systems of ODEs as vector questions
  - Conversion of an nth-order ODE to a system
  - The basic theory of systems of ODEs - Wronskian
  - Phase plane method
  - Critical points of the system
  - Criteria for critical points - stability [Tutorial]

Partial Differential Equations (Book 2, Chapter 13)

- Partial Differential Equations (PDEs) (1 Lecture)
  - Basic Concepts of PDEs
  - Laplace's equation - steady state temperature in a rectangular plate and solution by separation of variables.
- Heat Equation (3 Lectures + 1 Tutorial)
  - Derivation of the heat equation
  - Solution by the method of separation of variables, use of Fourier series
  - Steady two-dimensional heat problems - Laplace's equation
  - Insulated boundaries
  - Applications in physics: The Schrodinger equation, heat conduction, diffusion processes (Tutorial)
- Wave Equation (2 Lectures + 1 Tutorial)

    - Derivation of the wave equation
    - The vibrating string - Solution by the method of separation of variables and Fourier series.
- Applications in physics (3 Lectures)
    - Steady-state temperature in a cylinder
    - Vibration of a circulation membrane
    - Steady-state temperature in a sphere
- Laplace’s and Poisson’s Equations (1 Lecture)
    - Laplace's and Poisson's equations in electrostatics

Textbook:

1 Advanced Engineering Mathematics (10th Edn.), Erwin Kreyzing, John Wiley
2 Mathematical Methods in the Physical Sciences (3rd Edn.), Mary L. Boas, Cambridge University Press.

Reference:

1 Mathematical Methods for Physicists, Arfken & Weber (7th edition), Academic Press.
2 Mathematical Methods for Physics and Engineering (3rd Edn.), K.F. Riley, M.P. Hobson, and S.J. Bence, CUP.
3 Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow, CUP.
4 A Student’s Guide to Fourier Transforms, JFJ James, CUP
5 A Student’s Guide to Vectors and Tensors, Daniel Fleisch, CUP
6 A Primer on Scientific Programming with Python, Langtangen, H.P, Springer.
7 Python for Data Analysis, Wes McKinney

MSPHN01C03 – Electrodynamics

(Contact hours -72 hours (54 Lectures + 18 Tutorials)

Course Objectives:

The course aims to develop a deep understanding of the fundamental principles and concepts of classical electrodynamics by probing the nature of two interconnected phenomena, electricity and magnetism. The course will help to gain proficiency in solving complex problems related to electrodynamics and to acquire the ability to apply mathematical techniques and analytical methods to derive and manipulate Maxwell's equations. This course will also introduce the principles of electromagnetic radiation, including the generation, propagation and the concept of special relativity and its connection to electrodynamics, including relativistic transformations and their implications to foster critical thinking skills to analyse and tackle advanced topics in classical electrodynamics.

Module 1: Electrostatic Boundary - Value Problems (10L + 3T)

Poisson's equation and Laplace's equation- Laplace's Equation in one, two and three dimensions - Uniqueness Theorems - Method of images - Laplace equation in Cartesian, spherical and cylindrical coordinates - Boundary value problems with linear dielectrics
(Chapter-3, Sections 3.1 to 3.3& Chapter 4, Sections 4.4.2 of T1).

(Tutorial Problems- Problems 3.23to 3.25 & 4.22 of T1).

Module 2: Electromagnetic waves and Waveguides (24L + 6T)

The Generalization of Ampere's law - Maxwell's equations and their empirical basis- Electromagnetic energy: Pointing vector - The wave equation - Boundary conditions– Plane Electromagnetic waves in a non-conducting media – Polarization – Energy density and flux - Plane monochromatic waves in a conducting media. Reflection and refraction of electromagnetic waves at the boundary of two non-conducting media for oblique incidence – Brewster angle, Critical angle -Rectangular waveguides - Transverse magnetic (TM) modes -Transverse electric (TE) modes - Wave propagation in the wave guide
(Chapter-16, Sections 16. 1 to 16.5, Chapter-17, Sections 17.1 to 17.4 of T2& Chapter 12, Sections 12.2 to 12.5 of T3).

(Tutorial Problems- Problem 10.1, 10.9, 10.20, 10.26, 10.34, 10.35, 12.1 & 12.25 of T3).

Module 3: Radiation (12L+4T)

Scalar and vector potential - Gauge Transformations - Coulomb Gauge and Lorenz Gauge -Retarded Potentials - Jefimenko's Equations - Liénard – Wiechert Potentials - Electric dipole radiation - Magnetic dipole radiation - Power Radiated by a Point Charge: Larmor formula – Radiation reaction: The Abraham-Lorentz formula.

(Chapter-10, Sections 10.1.1 to 10.3.1 & Chapter 11, Sections 11.1.2, 11.1.3, 11.2.1 and 11.2.2 of T1).

(Tutorial Problems- Problems 10.1, 10.3, 10.13 & 11.13 of T1).

Module 4: Relativistic electrodynamics(11L+2T)

Basic concepts of Lorentz Transformation – Geometry of spacetime – Lorentz transformation as an orthogonal transformation – Covariant form of electromagnetic equations like continuity equation, Maxwell's equations etc – The electromagnetic field tensor – Transformation law for the electromagnetic field.

(Chapter-22, Sections 22.2 to 22.6 of T2).

(Tutorial Problems- Problems 12.46 & 12.52 ofT1)

Books for study

1 Introduction to Electrodynamics, Third edition, David J Griffiths, Prentice Hall India.
2 Foundations of electromagnetic Theory, John R.Reitz, Frederic J Milford, Robert W Christy,Third Edition, Narosa Publishing House.
3 Elements of Electromagnetic, Mathew N. O Sadiku, Seventh Edition, Oxford University Press.

References

1 Classical electrodynamics, John David Jackson, Third edition, John Wiley & Sons Inc.
2 Classical electrodynamics, Walter Greiner, First edition, Springer- Verlag, New York, Inc.
3 Electromagnetics, John D.Kraus, Second Edition,McGraw-Hill International.
4 Field and Wave electromagnetics, D.K.Cheng, Second Edition ,Addison Wesley.
5 Schaum's Outlines, Electromagnetics, 4th Edition (Schaum_s Outline Series), McGraw Hill.
6 Solved Problems in Classical Electromagnetism: Analytical and Numerical Solutions with Comments, First Edition, Oxford University Press.

Course Outcomes:

Upon completion of this course, students should be able to:

1 Understand the fundamental principles and concepts of classical electrodynamics.
2 Analyze and interpret electromagnetic fields, potentials, Maxwell's equations and their implications.
3 Describe the behaviour of electromagnetic waves in different media.
4 Understand the interaction of electromagnetic waves with matter, including reflection and transmission phenomena.
5 Understand the principles of electromagnetic radiation and waveguides.
6 Apply the principles of electrodynamics in the context of special relativity.
7 Enhance problem-solving and critical-thinking skills through tutorials and exercises
8 Acquire a solid foundation in electromagnetism, laying the groundwork for further research or specialization in related fields.

MSPHN01C04-Electronics

Contact hours -72 (54 Lectures + 18 Tutorials)

Course Objectives

The course will introduce students to different electronic devices and systems commonly used in various applications. This includes operational amplifiers, oscillators, filters, power supplies, digital logic circuits & microprocessors. Students will learn to design and analyze electronic circuits, including analogue and digital circuits. This course typically involves solving circuit problems and troubleshooting faulty circuits. Students will develop their analytical and problem-solving skills, allowing them to identify and rectify circuit issues effectively.

Course Outcomes

After completion of this course, the students will be able to:

1. Explain the theory, working and applications of OPAMP (Module 1)
2. Understand the applications of the OPAMP with special reference to filters, oscillators etc (Module 2)
3. Appreciate combinational circuits, Sequential circuits, D/A & A/D converters (Module 3)
4. Apprehend the architecture of the 8085 Microprocessor. (Module 4)

Module 1: OPERATIONAL AMPLIFIER & APPLICATIONS (12 L + 8 T)

Operational Amplifier- Differential amplifier circuit using transistors *(Book 1: 10.2)*
The Operational Amplifier- Block Diagram Representation of a Typical OPAMP-Schematic Symbol- Integrated Circuits-Power Supplies for Integrated Circuits- The Ideal OPAMP- Equivalent Circuit of an OPAMP- Ideal Voltage Transfer Curve- Open Loop Configurations- Block diagram representation of feedback configurations- Block Diagram Representation of Feedback Configurations- Voltage series feedback amplifier- Voltage shunt feedback amplifier-The Practical OPAMP - Input offset Voltage (Offset- Voltage Compensating Network design *not required*)-Input Bias Current-Input Offset Current-Total Output Offset voltage-Common Mode Configuration & CMRR- Frequency Response-Compensating Networks- High-frequency OPAMP Equivalent circuit- Open-loop Voltage gain as a function of frequency- Closed loop frequency response- Slew Rate- Summing Scaling and Averaging Amplifiers- Voltage to Current Converter (with Floating Load and Grounded Load) [*Basic idea only*]- Current to Voltage Converter- DAC using I to V Converter-The Integrator- The Differentiator
(Book 2: 1.2, 1.3, 1.5, 1.6,1.13, 2.3, 2.4, 2.5, 2.6,3.1,3.2, 3.3, 3.4,4.1,4.2, 4.3, 4.4,4.5,4.11, 5.2,5.3, 5.6,5.7, 5.8, 5.10, 6.5,6.8, 6.9,6.10,6.12 & 6.13)

Module 2: ACTIVE FILTERS & NON-LINEAR APPLICATIONS (14 L + 6 T)

Introduction-Active filters -First order low-pass Butterworth Filter- First order high pass Butterworth filter- Oscillators-Square wave generator-triangular wave generator-sawtooth wave generator- Basic Comparator-Zero Crossing Detector- Schmitt Trigger-Comparator Characteristics-Limitations of OPAMP as Comparator- Voltage Limiters
(Book 2: 7.1, 7.2, 7.3, 7.5, 7.11, 7.15, 7.16, 7.17, 8.2, 8.3, 8.4,8.5, 8.6, 8.7)

Module 3: DIGITAL ELECTRONICS (18 L+ 4 T)
Multiplexers- Applications of Multiplexers-Demultiplexers *(Book 3: 7.24, 7.25 & 7.26)*
Flip-flops and Timing circuits: Introduction- Classification of sequential circuits- Level mode & pulse mode asynchronous sequential circuits- Latches and flip flops- Asynchronous inputs- flip-flop operating characteristics-Clock skew and time race- Race around condition-Master slave flip flops-flip flop excitation table- conversion of flip flops- application of flip flops
(Book 3: 10.1 to 10.12)
Shift registers: Introduction-Buffer register- Controlled Buffer register- Data transmission in shift register- SISO Shift Register- SIPO Shift Register - PISO Shift Register - PIPO Shift Register-Bidirectional Shift Register- Universal Shift Register- Application of Shift Register
(Book 3: 11.1, 11.2, 11.3, 11.4, 11.5,11.6,11.7 11.8, 11.9, 11.10 &11.12)
Counters: Introduction- Asynchronous (ripple) counters- Design of Asynchronous counters Effect of propagation delay in ripple counters- Synchronous counters- Design of Synchronous counters- (3-bit Up-down, 3-bit Up, 3-bit Down, Modulo-10 Up/ Down synchronous counter)
(Book 3: 12.1,12.2, 12.3,12.4,12.5,12.5.1,12.5.2,12.5.3,12.5.4 & 12.5.5)
Analog to Digital & Digital to Analog Converters: Introduction- Digital to Analog conversion- The R-2R ladder type DAC- The weighted resistor type DAC- Analog to Digital Conversion- The counter type ADC—The Successive approximation type ADC
(Book 3: 17.1, 17.2, 17.3, 17.4, 17.7,17.8 & 17.12)
Module 4: Microprocessors (8 L + 2 T)
Introduction- Microprocessors & Microcontrollers-Microprocessor Based Systems- Origin of Microprocessors- Classification of Microprocessors- Technology Improvements adapted to Microprocessors and Computers-Introduction to 8085 Microprocessors- Architecture of 8085 Microprocessors.
(Book 4: 1.1, 1.3, 1.4, 1.5, 1.6, 1.9, 2.1 & 2.2)

Books for study
1 Electronic Devices and Circuit Theory (Eleventh Edition)- Robert L. Boylested & Louis Nashelsky (PHI)
2 OPAMPs and Linear Integrated Circuits (Fourth Edition)- Ramakanth A. Gayakwad (Pearson)
3 Fundamentals of Digital Circuits (Fourth Edition) - A. Anand Kumar (PHI)
4 Microprocessors & Microcontrollers – N Senthil Kumar, M Saravanan & S Jeevananthan Oxford University Press (2013)
References
1. Electronics Fundamentals Circuits, Devices & Applications- Thomas L Floyd & David L Buchla (Pearson)
2. Modern Digital Electronics – R P Jain (TMH)
3. Microprocessor Architecture, Programming, and Applications with the 8085/8080A- Ramesh.S.Gaonkar (Penram)

MSPHN01C05 & MSPHN02C05 - Practical I – Basic Physics Laboratory

(At least 12 experiments should be done by choosing at least 8 experiments from cluster I and 4 experiments from cluster II)

Course Objectives

This course is designed to provide students with hands-on experience and practical training in various experimental techniques and methods used in physics. It applies concepts and principles learned in theoretical physics courses to design and conduct experiments.

Course Outcomes

1.1 Develop proficiency in setting up and conducting physics experiments using various scientific instruments.
1.2 Understand the principles of instrumentation and calibration processes to ensure accurate measurements.
1.3 Develop the ability to troubleshoot experimental setups and address technical issues.
2 Develop skills in collecting and analysing experimental data, including the use of statistical tools and software for data processing.
3 Improve scientific writing skills to present experimental results in a clear and concise manner.
4 Encourage critical analysis of experimental results and drawing valid conclusions.

Cluster I

(At least 8 experiments should be done)

4.1 Determine the coefficient of viscosity of the given liquid by the oscillating disc method.
4.2 Determine the Young's modulus and Poisson's ratio of the material of the given bar by Koenig's method.
4.3 Determine mode constants of the given strip. Find the frequency of vibration of the strip by Melde's method and Young's modulus by cantilever method.
4.4 Determine Young's modulus, Poisson's ratio and bulk modulus of Pyrex/glass by forming Cornu’s hyperbolic/elliptical fringes.
4.5 Measure the wavelengths of the standard lines of the Hg spectrum using the diffraction grating. Determine the Cauchy's constants of the given prism. Hence find the wavelengths of sodium light.
4.6 Determine Stefan's constant of a black body using the given apparatus.
4.7 Determine the thermoelectric constants, neutral temperature and temperature of inversion of the given thermocouple by measuring the thermo emf at various temperatures using a calibrated potentiometer.

or

Determine the thermoelectric constants, neutral temperature and temperature of inversion of three different thermocouples by measuring the thermo emf at various temperatures using a microvoltmeter.

4.8 Determine the coefficient of thermal conductivity of the given liquid/powder and air by the Lee's disc method using thermocouple and BG/Potentiometer.

4.9 Study the variation of magnetic susceptibility of the given paramagnetic solution for different concentrations by Quincke’s method. Measure the magnetic flux density either by using search coil and HMS or search coil and standard solenoid.

4.10 Study the magnetic hysteresis of the given specimen using BG/CRO. Draw the B-H curve and find the retentivity, coercivity and energy lost per cycle of magnetization.

4.11 Determine the surface tension of water at different temperatures by Jaeger's method of observing the air bubble diameter at the instant of bursting inside water.

4.12 Determine Young’s Modulus, Rigidity modulus and Poisson’s ratio of the material of a given wire by Searle’s dynamical method.

4.13 Analyze a linearly polarised light, verify Malu’s law, rotate the state of polarisation of a linearly polarised light using half wave plate and conversion of linearly polarised light into elliptically/circularly polarised light using quarter wave plate.

4.14 Determine the thermal expansion coefficient of a metal using single slit diffraction.

Cluster II

(At least 4 experiments should be done)

1.1 Determine the resistance and self-inductance of a given coil using Maxwell’s LC Bridge. Repeat the experiment for different frequencies and evaluate the Q-factor for those frequencies.

1.2 Find the self-inductance of the given coil using Anderson’s bridge.

1.3 Determine the diameter of a thin wire and wavelength of light from the diffraction pattern using a laser beam.

or

Plot the beam profile of a given laser and measure the divergence of the beam.

1.4 Determine the period of a compact disc from the diffraction pattern with a laser beam.

or

Determine the refractive index of a mirror substrate using a laser beam of known wavelength.

1.5 Verify Heisenberg's uncertainty principle using a single slit diffraction pattern.
1.6 Measure the wavelengths of different lines in the hydrogen spectrum (visible region) and calculate the Rydberg constant using diffraction grating and spectrometer.
1.7 Determine the dielectric constants of different liquids using Colpitts oscillator.
1.8 Determine the coefficient of viscosity of water by rotating cylinder method.

Reference Books

1 Advanced Practical Physics for Students – B. L. Worsnop & H. T. Flint, Methuen & Co. Ltd.
2 Practical Physics – R. K. Shukla & Anchal Srivastava – New Age International
3 Experimental Physics:Modern Methods – R. A. Dunlap,Oxford University Press
4 Methods of Experimental Physics – D.Malacara, Academic press
5 Practical Physics – S.L. Gupta & V. Kumar, Pragati Prakashan
6 MSc Practical Physics– C.J. Babu, Calicut University
7 Practical Physics – C. L. Arora, S. Chand & Company Ltd.
8 Advanced Practical Physics (Vol. I) – S. P. Singh, Pragati Prakashan

MSPHN01C06 & MSPHN02C06- Practical II – Electronics Laboratory

(At least 12 experiments should be done by choosing at least 6 experiments from cluster I, 4 experiments from cluster II and 2 experiments from cluster III)

Course Objectives

This course is intended to enable students with designing, analysis and implementation of electronic circuits for various applications. The course will facilitate students to connect theoretical knowledge with practical applications, fostering a deeper understanding of electronics principles.

Course Outcomes

1 Develop hands-on skills in using electronic equipment, tools and instruments commonly used in the electronics industry like oscilloscopes, signal generators, multimeters, soldering irons etc.
2 Gain proficiency in designing, building, and analysing electronic circuits, both analog and digital to perform specific functions like amplification, voltage regulation, signal generation, mathematical operations and digital operations using BJT/FET/ICs.
3 Learn how to identify and diagnose problems in electronic circuits and systems and develop effective strategies to debug and fix issues.
4 Improve scientific writing skills to present experimental results in a clear and concise manner.
5 Encourage critical analysis of experimental results and drawing valid conclusions.
6 Understand the importance of safety protocols when working with electronic components and systems.

Cluster I

(At least 6 experiments should be done)

1 Design and construct single stage common emitter amplifiers without and with negative feedback using BJT/FET. Compare the frequency responses and input and output impedances.
2 Design and construct a two stage RC coupled amplifier by coupling two identical single stage common emitter amplifiers using BJT/FET. Study the frequency response and measure its input and output impedances.
3 3.Design and construct a differential amplifier using transistors. Study the frequency response and measure its input impedance, output impedance and CMRR.
4 Design and set up a series voltage regulator with feedback using transistors and zener diodes to generate an output of 6V/9V at 300/500mA. Study its load and line regulation characteristics. Plot graphs using software.

5 Design and set up a series voltage regulator with feedback using IC 741 and zener diode to generate an output of 6V/9V at 300/500mA. Study its load and line regulation characteristics. Plot graphs using software.
6 Design and construct practical integrator and differentiator circuits using op amp. Plot the output waveforms for different input waveforms and study the frequency response for sinusoidal input.
7 Design and construct a Wien bridge oscillator using op amp. Measure the frequency and rms value of output. Use active clippers and clampers to get clipped and clamped output.
8 Construct low pass and high pass passive filters with C and R. Use these elements to construct first order low pass and high pass active filters. Compare the performance of the two filters.
9 Design and construct astable and monostable multivibrators using op amp.
10 Design and construct astable multivibrator and voltage-controlled oscillator using IC 555.

Cluster II

(At least 4 experiments should be done)

1 Design and construct a Schmitt trigger using an op amp for the desired LTP and UTP. Plot the waveforms, trace the hysteresis curve and verify the results.
2 Measure the important parameters (input offset voltage, input bias current, input offset current, CMRR and slew rate) of an opamp.
3 Design and set up low/high voltage regulators using IC 723 to generate output voltages of 6V/12V at 100mA. Study their load and line regulation characteristics. Plot graphs using software.
4 Design and construct a triangular wave generator using an op amp. Measure the frequency and rms value of output.
5 Design and construct a sawtooth wave generator using opamp/transistor. Measure the frequency of output.
6 Construct half wave and full wave precision rectifiers using op amp. Observe the output on CRO and study the circuit operation.
7 Design and construct a Darlington pair amplifier using medium power transistors for a suitable output current. Study the frequency response of the circuit and measure the input and output impedances.
8 Design and construct a circuit for solving a simultaneous equation using an op amp. Study the performance.
9 Design and construct a piezo-electric crystal oscillator to generate square waves of suitable frequencies. Compare designed and observed frequencies.
10 Design and construct an R.F oscillator using a tunnel diode. Measure frequency of the output signal.

Cluster III

(At least 2 experiments should be done)

1. Derive the Boolean expression for half adder and full adder from its truth tables and design it using 2 input NAND gates. Construct the circuit using IC 7400 and verify the truth tables.
2. Construct 4:1 Multiplexer and 1:4 Demultiplexer using gates (ICs 7400, 7404, 7411 & 7432) and verify their operation.
3. Construct RS, JK and D flip–flops using ICs (2 input NOR-7402, 2 input AND-7408, 2 input NAND-7400, 3 input NAND-7410, NOT-7404) and verify their truth tables.
4. Set up a four-bit shift register using IC 7495 and verify right shift and left shift operations for different data inputs.
5. Construct an up/down counter using JK flip-flop IC 7476 and verify its operation.
6. Construct Four-bit D/A Converters (i) Binary weighted resistor type and (ii) R-2R ladder type. Measure the analog outputs for different digital inputs and compare with theoretical values.

Reference Books

1. Basic Electronics: A Text lab manual – Paul B.Zbar, A. P. Malvino and M.A.C. Miller, McGraw Hill Education
2. The art of Electronics – Paul Horowitz and Winfield Hill, Cambridge University Press
3. Experiments in Digital Fundamentals – David M. Buchla, Pearson
4. Digital Electronics Practice using ICS– Jain R.P. and Anand M.M.S.,TMH.
5. Experiments in Electronics– Subramanian S.V., MacMillan
6. Electronic circuits : Fundamentals and applications-Mike Tooley, Routledge
7. Advanced Practical Physics (Vol. II) – S. P. Singh, Pragati Prakashan
8. Electronics Lab Manual (Vol I & Vol II) – K A Navas, Rajath Publishers

SYLLABUS

SEMESTER-II

MSPHN02C08 - Quantum Mechanics-I

(Contact hours -72 hrs (54 Lectures + 18 Tutorials))

Course Objectives

The main goal of this course is to provide an introductory understanding of the mathematical foundations and fundamental principles of quantum mechanics. Additionally, it covers important time-independent problems in both one-dimensional and three-dimensional scenarios within quantum Mechanics. Throughout the course, students will learn to formulate quantum mechanics using abstract mathematical concepts of linear vector spaces. They will also explore the core postulates of quantum mechanics and engage in discussions about key concepts such as state, observables, and time evolution. Furthermore, the course delves into both the Schrödinger and Heisenberg formulations of quantum mechanics, enabling students to gain a comprehensive understanding of these fundamental approaches. Moreover, students will analyze various time-independent problems that arise in one-dimensional and three-dimensional contexts in quantum mechanics.

Course Outcomes

1. Understand the Time-Independent Schrödinger Equation and its applications
2. Apply mathematical tools in Quantum Mechanics
3. Analyze the Theory of Angular Momentum
4. Recognize symmetries and conservation laws in quantum systems

Module 1: Time-Independent Schrödinger Equation (15L+4T)

Stationary States - Infinite Square Well-Harmonic Oscillator- Free Particle -Finite Square Well

(Book 1,Section 2.1 to 2.4, 2.6)

Schrödinger Equation in 3 dimensions- Hydrogen atom (Book 1, Section 4.1 to 4.2)

Module 2: Mathematical tools of Quantum Mechanics: (15L+6T)

Hilbert space and wave functions - Dirac notation – Operators - Representation in discrete bases - Representation in continuous bases (Book 2, Section 2.1 to 2.6)

Fundamental postulates – The equation of motion – Schrodinger, Heisenberg and Interaction pictures (*qualitative treatment only*) (Book 3– Section 3.1 and 4.1)

Module 3:Theory of Angular Momentum (12L+4T)

Orbital angular momentum – General formalism of angular momentum – Matrix representation of angular momentum – Spin angular momentum – Eigenfunctions of orbital angular momentum

(Book 2, Section 5.1 to 5.7)

Addition of angular momenta – General formalism - Clebsch - Gordan coefficients. (Book2, Section 7.3)

Module 4: Symmetry and Conservation Laws:(12L+ 4T)

Identical Particles - Two particle systems (Book 1- Section 5.1)

Symmetries & Conservation Laws- Introduction- Transformations in Space- The Translation Operator - Conservation Laws- Parity - Parity in One and three Dimensions - Parity selection rules - Rotational Symmetry- Degeneracy - Translations in time (Book1- Section 6.1 to 6.6, 6.8)

Books for study

1. David J. Griffiths, Darrell F. Schroeter - Introduction to Quantum Mechanics (3rd Edition, 2018, Cambridge University Press)
2. NouredineZettili, Quantum Mechanics – Concepts and Applications (2nd Edition, 2004, John Wiley & Sons)
3. V .K. Thankappan , Quantum Mechanics (5th Edition, 2019, New Age Publishers)

References:

1. Franz Schwabl - Quantum mechanics (2007, Springer)
2. J. J. Sakurai, Modern Quantum Mechanics (2nd edition, 2013, Pearson Education)
3. R. Shankar - Principles of quantum mechanics (1994, Plenum Press)
4. A. F. J. Levi - Applied quantum mechanics (2006, Cambridge University Press)
5. A.S. Davydov, Quantum Mechanics (2nd Ed., 1991, Pergamon)
6. Eugen Merzbacher, Quantum Mechanics (3rd Ed., Wiley, 1997)
7. Gary Bowman - Essential Quantum Mechanics (2008, Oxford University Press, USA)
8. Walter Greiner, D.A. Bromley - Quantum mechanics. An introduction (2000, Springer)
9. Hendrik F. Hameka - Quantum mechanics - a conceptual approach (2004, Wiley-Interscience)
10. AjoyGhatak, S Lokanathan - Quantum Mechanics- Theory and Applications (6th Edition, 2015, Trinity)

MSPHN02C09- Statistical Mechanics

(Contact hours -72 Hrs (54 Lectures + 18 Tutorials))

Course Objectives:

This course introduces students to statistical mechanics, which is part of the foundation of several branches of physics and has many applications beyond physics. The course demonstrates the profound consequences of an economical set of assumptions about nature known as the postulates of statistical mechanics. In particular, it shows how the postulates explain the general laws of thermodynamics as well as properties of classical and quantum gases, other condensed matter systems in equilibrium, and phase transitions.

Module 1: Statistical Basis of Thermodynamics & Elements of Ensemble Theory (9L+ 3T)

The macroscopic and microscopic states. - Boltzmann relation between entropy and microstates - Connection between statistics and thermodynamics-Classical ideal gas - Gibbs paradox -The correct enumeration of microstates - Phase space- Liouville's theorem and its significance, The microcanonical ensemble— Examples of calculation of microstates (Classical ideal gas and Simple Harmonic oscillator).

(Chapter-1 Sections 1.1 to 1.6, Chapter 2 Sections 2.1 to 2.4 of T1).

(Tutorial Problems- Section 4.7-1 to 6,11 of T2).

Module 2: Canonical and Grand canonical ensembles: (20L+4T)

a **Canonical ensemble**

Equilibrium between a system and reservoir, A system in the canonical ensemble - method of most probable values- Physical significance of statistical quantities in the canonical ensemble-Partition function for non-degenerate and degenerate systems- Density of states-The classical systems- Energy fluctuation in canonical ensemble; correspondence with the microcanonical ensemble, Equipartition theorem and virial theorem. A system of harmonic Oscillators.

(Chapter-3 Sections 3.1 to 3.8 of T1).

b **Grand canonical ensemble.**

Equilibrium between a system and a particle–energy reservoir, A system in Grand canonical ensemble-Physical Significance of statistical quantities- Examples in grand canonical ensemble, Classical ideal gas, a system of independent localized particles(Harmonic Oscillators), density and energy fluctuations in grand canonical ensemble correspondence with other ensembles.

(Chapter-4 Sections 4.1 to 4.5 of T1).

(Tutorial Problems- Section 5.7 of T2, Section 5.16 - 1 to 8,13,15,16,17 of T2).

Module 3: Quantum Statistical Mechanics (22L+6T)

a **Theory of Simple gases and Ideal Bose Systems**

An ideal gas in quantum mechanical micro canonical ensemble- An ideal gas in other quantum mechanical ensembles- statistics of occupation numbers.

(Chapter-6 Sections 6.1 to 6.3 of T1).

Thermodynamic behaviour of an ideal Bose gas-Bose-Einstein condensation - Thermodynamics of the blackbody radiation.

(Chapter-7 Sections 7.1 and 7.3 of T1).

b **Ideal Fermi Systems**

Thermodynamic behaviour of an ideal Fermi gas - Fermi temperature and Fermi energy- Magnetic behaviour of ideal Fermi gas –Pauli paramagnetism- Landau diamagnetism, Electron gas in metals.

(Chapter-8 Sections 8.1 to 8.3 of T1)

(Tutorial Problems- Problems 6.1, 7.21, 7.23, 7.24 of T1, Section 6.5 of T2, Section 6.9 - 1 to 5, Section 8.11 – 2,3,5,8, Section 10.6 – 2, 3, 8 of T2)

Module 4: Continuous Phase transitions (6L+2T)

Introduction, Ising model, Mean Field Theory, Order parameter ,Symmetry breaking Field, Critical Exponents.

(Chapter-12 Sections 12.1 to 12.6 of T2).

(Tutorial Problems- Section 12.7 -1,2 of T2)

Books for study

1. R K Pathria, Paul D. Beale - Statistical Mechanics, Fourth Edition (2022, Academic Press)
2. Roger Bowley, Mariana Sánchez - Introductory Statistical Mechanics, Second Edition (2000, Oxford University Press, USA)

References

1. Kerson Huang, Statistical Mechanics, Second edition, John Wiley and Sons (1987).

2 Mehran Kardar - Statistical Physics of Particles (2007, Cambridge University Press)
3 Silvio RA Salinas - Introduction to Statistical Physics (2010, Springer)
4 Ivo Sachs, Siddhartha Sen, James Sexton - Elements of statistical mechanics (2006, Cambridge University Press)
5 M. Glazer, J. S. Wark - Statistical mechanics- a survival guide (2001, Oxford University Press, USA)
6 D. TerHaar - Elements of statistical mechanics (1995, Butterworth-Heinemann)
7 Daniel C. Mattis - Statistical mechanics made simple- a guide for students and researchers (2003, World Scientific)
8 David Chandler - Introduction to modern statistical mechanics (1987, Oxford University Press)
9 Giuseppe Morandi - Statistical mechanics- An intermediate course (1996, World Scientific Publishing Company)
10 J. Woods Halley - Statistical mechanics- from first principles to macroscopic phenomena (2007, Cambridge University Press)
11 D.A.R Dalvit, J Frastai, Ian Lawrie - Problems on statistical mechanics (1999, Institute of Physics Pub)
12 NPTEL, Lecture Series on Classical Physics by Prof,V. Balakrishnan (Mod 1 Lec 20 to Lec 31)

Course Learning Outcomes:

Understand how a probabilistic description of nature at the microscopic level gives rise to deterministic laws at the macroscopic level. Relate the concepts of entropy and temperature as defined in statistical mechanics to their more familiar versions in thermodynamics. Solve for the thermal properties of classical and quantum gases and other condensed systems from a knowledge of their microscopic Hamiltonians. Appreciate that interactions between particles can explain the various phases of matter observed in nature as in phase transitions.

MSPHN02C10-Mathematical Physics II

Contact Hours: 72 hrs (54 Lectures + 18 Tutorials)

Course Learning Outcomes:

- **CSO1 - Develop a foundational understanding of complex numbers and functions:** including properties, analytical methods, and complex integration. Students should be able to apply these concepts to the study of physics, such as electrodynamics and quantum mechanics.
- **CSO2 - Laplace Transforms and Group Theory:** Learn to use Laplace transforms in physics problems. Additionally, gain a thorough understanding of the principles of group theory, including groups, subgroups, and group representations. Students should be able to identify and work with special groups such as unitary, orthogonal, and homogeneous Lorentz groups.
- **CSO3 - Numeric Analysis:** Equip students with the skills to conduct numerical analysis, such as error propagation, numerical integration and differentiation, and numerical methods for linear algebra. Students should be able to apply these techniques to solve ordinary and partial differential equations.
- **CSO4 - Probability and Statistics:** Provide students with a solid understanding of data analysis and probability theory, including random variables, probability distributions, and statistical methods. Students should be able to apply these concepts to the fields of hypothesis testing, quality control, and regression.
- **CSO5 - Apply mathematical methods to physical problems and promote computational skills:** The course aims to develop students' ability to use these mathematical methods to analyse and solve problems in physics. The tutorial sessions will particularly focus on practical applications, enhancing problem-solving skills. As part of the course, students will use computational tools to solve complex problems, enhancing their computational physics skills.

Module I: Complex Analysis (13L + 4T)

(Book 1, Chapters 13-16)

- **Complex Numbers and Functions** (3 Lectures)
  - Definitions and properties of complex numbers
  - Definition and examples of analytic functions
  - Cauchy-Riemann equations
  - Laplace’s Equation - Harmonic functions
  - Trigonometric and Hyperbolic Functions
  - Analyticity of the logarithm.
- **Complex Integration** (3 Lectures)
  - Line integrals in the complex plane
  - Cauchy's integral theorem
  - Cauchy's integral theorem for multiply connected domains

- Cauchy's integral formula
- Derivatives of analytic functions
- Liouville's theorem and the maximum modulus principle

- **Complex Power Series** (3 Lectures)
  - Definition and examples of complex power series
  - Convergence in the complex plane
  - Operations on complex power series
  - Taylor and Maclaurin series
- **Laurent Series - Residue Integration** (4 Lectures)
  - Laurent Series
  - Singularities and Zeros
  - Zeros of analytic functions
  - Residue integration method
  - Residue theorem
  - Residue integration of real integrals
- **Applications of Complex Analysis in Physics (4 Tutorials) (Book 1, Chapter 18)**
  - Electrodynamics: complex potentials, impedance
  - Quantum mechanics: wave functions, quantum states
  - Fluid dynamics: flow around objects, lift and drag

Module II: Laplace Transforms and Group Theory (13 Lectures + 4 Tutorials)

Laplace Transforms (4 Lectures + 1 Tutorial)

(Book 1, Chapter 6)

- Laplace transform - first shifting theorem, linearity
- Existing and Uniqueness of transforms
- Transforms of Derivatives and Integrals - ODEs
- Unit Step Function (Heaviside Function) - Second Shifting Theorem (t-Shifting)
- Short Impulses. Dirac's Delta Function
- Convolution
- Application to Nonhomogeneous Linear ODEs [Tutorial]

(Book 2, Chapter 12)

- Introduction to Group Theory (3 Lectures + 1 Tutorial)
  - Basic definitions: groups, subgroups, order, cyclic groups
  - Group multiplication table
  - Isomorphic and homomorphic groups
  - Group permutations and Cayley's theorem
- Subgroups and Representations of Groups (3 Lectures + 1 Tutorial)
  - Definition and properties of subgroups
  - Cosets, left and right cosets

        - Conjugate classes and Invariant subgroups
        - Group representations, Equivalent representations, reducible and irreducible representations
    - Special Groups (3 Lectures + 1 Tutorial)
        - Symmetry group
        - Unitary group U(1)
        - Orthogonal groups SO(2) and SO(3)
        - The SU(n) groups
        - Homogeneous Lorentz group [Tutorial]

Module III: Numeric Analysis (14 Lectures + 4 Tutorials)

(Book 1, Chapters 19-21)

- **Basic Ideas of Numerical Analysis (4 Lectures + 1 Tutorial)**
    - Errors in numeric results and error propagation
    - Solutions of equations by iteration
    - Newton's method of solving equations
    - Interpolation
    - Numeric Integration and Differentiation
    - Problems involving numerical analysis [Tutorial]

- **Numerical Linear Algebra (4 Lectures + 1 Tutorial)**
    - Linear systems - solution by iteration
    - Least squares method
    - Curve fitting by polynomials of degree m
    - Matrix eigenvalue problems
    - Problems [2 Tutorials]
- **Numerical methods for ODEs and PDEs (4 Lectures + 1 Tutorial)**
    - Methods for first-order ODEs
    - Multistep methods
    - Methods for systems and higher-order ODEs
    - Problems [1 Tutorial]

Module IV: Probability and Statistics (14 Lectures + 4 Tutorials)

(Book 1, Chap. 24-25)

- **Data Analysis and Probability Theory (7 Lectures + 2 Tutorials)**
    - Data representation, events
    - Probability theorems
    - Permutations and combinations
    - Random variables, probability distributions
    - Mean and Variance of a distribution
    - Binomial, Poisson, Hypergeometric, and Normal distributions

    - Distributions of several random variables
    - Applied Problems [2 Tutorials]
- **Mathematical Statistics (7 Lectures + 2 Tutorials)**
    - Random sampling
    - Point Estimation of Parameters
    - Confidence Intervals
    - Testing of Hypotheses
    - Quality control
    - Goodness of fit
    - Nonparametric tests
    - Regression
    - Applied Problems [2 Tutorials]

Textbooks:

1. Advanced Engineering Mathematics (10th Edn.), Erwin Kreyzing, John Wiley
2. Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow, CUP.

References:

1. Mathematical Methods for Physicists, Arfken& Weber (Seventh edition), Academic Press.
2. Mathematical Methods in the Physical Sciences (3rd Edn), Mary L. Boas, CUP
3. Mathematical Methods for Physics and Engineering (3rd Edn.), K.F. Riley, M.P. Hobson, and S.J. Bence, CUP.
4. A Primer on Scientific Programming with Python, Langtangen, H.P., Springer, "
5. Python for Data Analysis" by Wes McKinney
6. A Student's Guide to Fourier Transforms, JFJ James, CUP
7. A Student's Guide to Vectors and Tensors, Daniel Fleisch, CUP
8. Group Theory in Physics: An Introduction, J F Cornwell, Academic Press.
9. Group Theory in a Nutshell for Physicists, A. Zee.
10. An Introduction to Tensors and Group Theory for Physicists, Jeevanjee, N.
11. A Gentle Course in Tensor Analysis, David Kay.
12. "Gravitation" by Charles Misner, Kip Thorne, and John Wheeler.
13. "Differential Geometry and its Applications" by John Oprea.
14. "A First Course in General Relativity" by Bernard Schutz,

MSPHN02C11: SPECTROSCOPY

Contact hours - 72 Hrs (54 Lectures + 18 Tutorial)

Course Objectives:

CO1: Understand structure of atom from the atomic spectra
CO2: Understand vector atom model through space quantization
CO3: Understand the influence of external magnetic and electric field on the atomic system
CO4: Understand the microwave and infrared spectroscopy techniques of the molecular system
CO5: Understand the electronic and Raman spectroscopy techniques of the molecular system
CO6: Understand nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectroscopy techniques
CO7: Understand Mossbauer spectroscopy and its applications

Module 1: Atomic spectroscopy

Introduction to atomic spectroscopy, hydrogen atom and the three quantum numbers (n, l and m_l), spectra of hydrogen-like ions, spectra of the alkali metals, elements with more than one outer valence electron, forbidden transitions and selection rules, space quantization, normal Zeeman effect, anomalous Zeeman effect, magnetic moment of the atom and g factor, emitted frequencies in anomalous Zeeman transitions, the Lande g formula, Paschen Back effect, Stark effect (sections 1.1, 1.1.1, 1.1.2, 1.2.1, 1.3, 1.4, 1.5, 1.6, 1.7, 1.7.1, 1.8.1, 1.8.2, 1.8.3, 1.8.4, 1.8.5, 1.9 and 1.10.1 of book 1).

14L+4T Hrs.

Module 2: Microwave and infrared spectroscopy

Part A: Review of the rotation of molecules, rigid diatomic molecule, intensities of spectral lines, effect of isotopic substitution, non-rigid rotator and the spectrum, linear polyatomic molecule, symmetric top molecule (sections 2.1, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.3.5, 2.4.1 and 2.4.2 of book 2).

5L+2T Hrs.

Part B: Review of the spectra of vibrating diatomic molecule as simple harmonic oscillator, anharmonic oscillator, the diatomic vibrating rotator, the vibration -rotation spectrum of carbon monoxide, breakdown of Born-Oppenheimer approximation, vibrations of polyatomic molecules, influence of rotation on the spectra of polyatomic molecules (sections 3.1.1, 3.1.2, 3.1.3, 3.2, 3.3, 3.4, 3.5.1, 3.6.1, 3.6.2 and 3.6.3 of book 2).

8L+3T Hrs.

Module 3: Electronic and Raman spectroscopy

Part A: Born-Oppenheimer approximation, vibrational coarse structure, progressions, Frank-Condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibrational transitions, Fortrat diagram, pre-dissociation (sections 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5, 6.1.6 and 6.1.7 of book 2).

7L+2T Hrs.

Part B: Quantum theory of Raman Effect, classical theory of Raman Effect, pure rotational Raman spectra of linear molecules and symmetric top molecules, Raman activity of vibrations, rule of mutual exclusion, vibrational Raman spectra, rotational fine structure, Raman spectrometer (sections 4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.3.4, 4.3.5 and 4.6 of book 2).

7L+2T Hrs.

Module 4: Spin Resonance and Mossbauer spectroscopy

Nature of spinning particles, interaction between spin and a magnetic field, population of energy levels, Larmor precession, NMR spectroscopy-Hydrogen nuclei, chemical shift, ESR spectroscopy, the position of ESR absorptions, principles of Mossbauer spectroscopy, applications-chemical shift, Quadrupole effects, effect of magnetic field (sections 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.2, 7.2.1, 7.5.1, 7.5.2, 9.1, 9.2.1, 9.2.2 and 9.2.3 of book 2).

13L+5T Hrs.

Books for study:

1. B. P. Straughan& S. Walker, Spectroscopy, Volume1, Chapman and Hall.
2. Colin N. Banwell and Elaine M. McCash, Fundamentals of Molecular Spectroscopy (4^{th} Edition), McGraw-Hill Publishing Company.

Books for reference:

1. H. E. White, Introduction to Atomic Spectra, McGraw Hill.
2. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India.
3. Rita Kakkar, Atomic and Molecular Spectroscopy Basic Concepts and Applications, Cambridge.
4. K. P. Rajappan Nair, Atomic Spectroscopy, MJP Publishers.
5. K. P. Rajappan Nair, Atoms, Molecules and Lasers, Alpha Science.

Course Learning Outcomes: The students will have achieved the ability to

1. Illustrate the structure and properties of isolated atoms and molecules and their interaction with electromagnetic radiation
2. Demonstrate the change in behavior of atoms in external applied magnetic and electric field
3. Describe rotational, vibrational, electronic and Raman spectra of molecules

4 Illustrate nuclear magnetic and electron spin resonance spectroscopy and their applications
5 Understand usefulness of spectroscopic techniques and applications in research and development.

Seminar Topics (not limited to)

1 Atomics models
2 Structure of atom
3 Spin-Orbit interaction
4 Characterization of electromagnetic radiation
5 Electromagnetic spectrum
6 Quantum numbers
7 Quantization of energy
8 Interaction of energy with matter
9 Types of molecules
10 Laser fundamentals

Self Study Topics: (not limited to)

1 Basics of atomic spectroscopy and quantum numbers
2 Effect of magnetic and electric field on the atomic structure
3 Molecule classification and rotation of rigid diatomic molecule
4 Vibrating diatomic molecule as simple harmonic oscillator
5 Absorption and emission of energy by molecule
6 Raman scattering
7 Electron spin and nature of spinning particle

MSPHN01C05 & MSPHN02C05- Practical I – Basic Physics Laboratory

(At least 12 experiments should be done by choosing at least 8 experiments from cluster I and 4 experiments from cluster II)

Course Objectives

This course is designed to provide students with hands-on experience and practical training in various experimental techniques and methods used in physics. It applies concepts and principles learned in theoretical physics courses to design and conduct experiments.

Course Outcomes

1.1 Develop proficiency in setting up and conducting physics experiments using various scientific instruments.
1.2 Understand the principles of instrumentation and calibration processes to ensure accurate measurements.
1.3 Develop the ability to troubleshoot experimental setups and address technical issues.
2 Develop skills in collecting and analysing experimental data, including the use of statistical tools and software for data processing.
3 Improve scientific writing skills to present experimental results in a clear and concise manner.
4 Encourage critical analysis of experimental results and drawing valid conclusions.

Cluster I

(At least 8 experiments should be done)

4.1 Determine the coefficient of viscosity of the given liquid by the oscillating disc method.
4.2 Determine the Young's modulus and Poisson's ratio of the material of the given bar by Koenig's method.
4.3 Determine mode constants of the given strip. Find the frequency of vibration of the strip by Melde's method and Young's modulus by cantilever method.
4.4 Determine Young's modulus, Poisson's ratio and bulk modulus of Pyrex/glass by forming Cornu's hyperbolic/elliptical fringes.
4.5 Measure the wavelengths of the standard lines of the Hg spectrum using the diffraction grating. Determine the Cauchy's constants of the given prism. Hence find the wavelengths of sodium light.
4.6 Determine Stefan's constant of a black body using the given apparatus.
4.7 Determine the thermoelectric constants, neutral temperature and temperature of inversion of the given thermocouple by measuring the thermo emf at various temperatures using a calibrated potentiometer.

or

Determine the thermoelectric constants, neutral temperature and temperature of inversion of three different thermocouples by measuring the thermo emf at various temperatures using a microvoltmeter.

4.8 Determine the coefficient of thermal conductivity of the given liquid/powder and air by the Lee's disc method using thermocouple and BG/Potentiometer.

4.9 Study the variation of magnetic susceptibility of the given paramagnetic solution for different concentrations by Quincke's method. Measure the magnetic flux density either by using search coil and HMS or search coil and standard solenoid.

4.10 Study the magnetic hysteresis of the given specimen using BG/CRO. Draw the B-H curve and find the retentivity, coercivity and energy lost per cycle of magnetization.

4.11 Determine the surface tension of water at different temperatures by Jaeger's method of observing the air bubble diameter at the instant of bursting inside water.

4.12 Determine Young's Modulus, Rigidity modulus and Poisson's ratio of the material of a given wire by Searle's dynamical method.

4.13 Analyze a linearly polarised light, verify Malu's law, rotate the state of polarisation of a linearly polarised light using half wave plate and conversion of linearly polarised light into elliptically/circularly polarised light using quarter wave plate.

4.14 Determine the thermal expansion coefficient of a metal using single slit diffraction.

Cluster II

(At least 4 experiments should be done)

1.1 Determine the resistance and self-inductance of a given coil using Maxwell's LC Bridge. Repeat the experiment for different frequencies and evaluate the Q-factor for those frequencies.

1.2 Find the self-inductance of the given coil using Anderson's bridge.

1.3 Determine the diameter of a thin wire and wavelength of light from the diffraction pattern using a laser beam.

or

Plot the beam profile of a given laser and measure the divergence of the beam.

1.4 Determine the period of a compact disc from the diffraction pattern with a laser beam.

or

Determine the refractive index of a mirror substrate using a laser beam of known wavelength.

1.5 Verify Heisenberg's uncertainty principle using a single slit diffraction pattern.
1.6 Measure the wavelengths of different lines in the hydrogen spectrum (visible region) and calculate the Rydberg constant using diffraction grating and spectrometer.
1.7 Determine the dielectric constants of different liquids using Colpitts oscillator.
1.8 Determine the coefficient of viscosity of water by rotating cylinder method.

Reference Books

1 Advanced Practical Physics for Students – B. L. Worsnop & H. T. Flint, Methuen & Co. Ltd.
2 Practical Physics – R. K. Shukla & Anchal Srivastava – New Age International
3 Experimental Physics:Modern Methods – R. A. Dunlap,Oxford University Press
4 Methods of Experimental Physics – D.Malacara, Academic press
5 Practical Physics – S. L. Gupta, V. Kumar, Pragati Prakashan
6 MSc Practical Physics– C.J. Babu, Calicut University
7 Practical Physics – C. L. Arora, S. Chand & Company Ltd.
8 Advanced Practical Physics (Vol. I) – S. P. Singh, Pragati Prakashan

MSPHN01C06 & MSPHN02C06- Practical II – Electronics Laboratory

(At least 12 experiments should be done by choosing at least 6 experiments from cluster I, 4 experiments from cluster II and 2 experiments from cluster III)

Course Objectives

This course is intended to enable students with designing, analysis and implementation of electronic circuits for various applications. The course will facilitate students to connect theoretical knowledge with practical applications, fostering a deeper understanding of electronics principles.

Course Outcomes

1. Develop hands-on skills in using electronic equipment, tools and instruments commonly used in the electronics industry like oscilloscopes, signal generators, multimeters, soldering irons etc.
2. Gain proficiency in designing, building, and analysing electronic circuits, both analog and digital to perform specific functions like amplification, voltage regulation, signal generation, mathematical operations and digital operations using BJT/FET/ICs.
3. Learn how to identify and diagnose problems in electronic circuits and systems and develop effective strategies to debug and fix issues.
4. Improve scientific writing skills to present experimental results in a clear and concise manner.
5. Encourage critical analysis of experimental results and drawing valid conclusions.
6. Understand the importance of safety protocols when working with electronic components and systems.

Cluster I

(At least 6 experiments should be done)

1. Design and construct single stage common emitter amplifiers without and with negative feedback using BJT/FET. Compare the frequency responses and input and output impedances.
2. Design and construct a two stage RC coupled amplifier by coupling two identical single stage common emitter amplifiers using BJT/FET. Study the frequency response and measure its input and output impedances.
3. 3.Design and construct a differential amplifier using transistors. Study the frequency response and measure its input impedance, output impedance and CMRR.
4. Design and set up a series voltage regulator with feedback using transistors and zener diode to generate an output of 6V/9V at 300/500mA. Study its load and line regulation characteristics. Plot graphs using software.

5 Design and set up a series voltage regulator with feedback using IC 741 and zener diode to generate an output of 6V/9V at 300/500mA. Study its load and line regulation characteristics. Plot graphs using software.

6 Design and construct practical integrator and differentiator circuits using opmap. Plot the output waveforms for different input waveforms and study the frequency response for sinusoidal input.

7 Design and construct a Wien bridge oscillator using opmap. Measure the frequency and rms value of output. Use active clippers and clampers to get clipped and clamped output.

8 Construct low pass and high pass passive filters with C and R. Use these elements to construct first order low pass and high pass active filters. Compare the performance of the two filters.

9 Design and construct a stable and mono stable multi vibrators using opamp.

10 Design and construct as table multi vibrator and voltage controlled oscillator using IC 555.

<u>Cluster II</u>

(At least 4 experiments should be done)

1 Design and construct a Schmitt trigger using opmap for the desired LTP and UTP. Plot the waveforms, trace the hysteresis curve and verify the results.

2 Measure the important parameters (input offset voltage, input bias current, input offset current, CMRR and slew rate) of an opamp.

3 Design and set up low/high voltage regulators using IC 723 to generate output voltages of 6V/12V at 100mA. Study their load and line regulation characteristics. Plot graphs using software.

4 Design and construct a triangular wave generator using opmap. Measure the frequency and rms value of output.

5 Design and construct a sawtooth wave generator using opamp/transistor. Measure the frequency of output.

6 Construct half wave and full wave precision rectifiers using opmap. Observe the output on CRO and study the circuit operation.

7 Design and construct a Darlington pair amplifier using medium power transistors for a suitable output current. Study the frequency response of the circuit and measure the input and output impedances.

8 Design and construct a circuit for solving a simultaneous equation using opmap. Study the performance.

9 Design and construct a piezo-electric crystal oscillator to generate square waves of suitable frequencies. Compare designed and observed frequencies.

10 Design and construct an R.F oscillator using a tunnel diode. Measure frequency of the output signal.

Cluster III

(At least 2 experiments should be done)

1 Derive the Boolean expression for half adder and full adder from its truth tables and design it using 2 input NAND gates. Construct the circuit using IC 7400 and verify the truth tables.
2 Construct 4:1 Multiplexer and 1:4 Demultiplexer using gates (ICs 7400, 7404, 7411 & 7432) and verify their operation.
3 Construct RS, JK and D flip–flops using ICs (2 input NOR-7402, 2 input AND-7408, 2 input NAND-7400, 3 input NAND-7410, NOT-7404) and verify their truth tables.
4 Set up a four bit shift register using IC 7495 and verify right shift and left shift operations for different data inputs.
5 Construct an up/down counter using JK flip-flop IC 7476 and verify its operation.
6 Construct Four-bit D/A Converters (i) Binary weighted resistor type and (ii) R-2R ladder type. Measure the analog outputs for different digital inputs and compare with theoretical values.

Reference Books

1 Basic Electronics: A Text lab manual – Paul B.Zbar, A. P. Malvino and M. A. Miller, McGraw Hill Education
2 The art of Electronics – Paul Horowitz and Winfield Hill, Cambridge University Press
3 Experiments in Digital Fundamentals – David M. Buchla, Pearson
4 Digital Electronics Practice using ICS– JainR.P. andAnandM.M.S.,TMH.
5 Experiments in Electronics– Subramanian S.V., MacMillan
6 Electronic circuits: Fundamentals and applications-MikeTooley, Routledge
7 Advanced Practical Physics (Vol. II) – S. P. Singh, Pragati Prakashan
8 Electronics Lab Manual (Vol I & Vol II) – K A Navas, Rajath Publishers

SYLLABUS

SEMESTER-III

MSPHN03C13: QUANTUM MECHANICS II (4C)

(Contact hours -72 hrs (54 Lectures+ 18 Tutorials))

Course Objectives

The course aims to enhance students' comprehension and practical application of diverse approximation methods, including time-independent perturbation theory, the variational method, WKB approximation and time dependent perturbation theory. Additionally, students will delve into the theory of scattering. Lastly, the course will introduce relativistic quantum mechanics and field quantization.

Course Outcomes

C01: Demonstrate a thorough understanding of various approximation methods

C02: Understand the time dependent perturbation theory and its applications

C03: Analyse and interpret the theory of scattering,

C04: Develop familiarity with relativistic quantum mechanics and then the importance of the theory of field quantization.

Module 1: Approximation methods for stationary states: (14L+5T)
Time independent perturbation theory - nondegenerate and degenerate cases – Fine structure of Hydrogen – the relativistic correction (Book 1, Section 7.1 to 7.3) Variational Principle - Theory - Ground state energy of He atom (Book 1, Section 8.1 to 8.2) WKB approximation - Classical region - Tunneling - connection formulae (Book1, Section 9.1 to 9.3)

Module 2: Time dependent perturbation theory: **(12L+4T)**
Time dependent perturbation theory – Transition probability, Transition probability for a constant Perturbation – Transition probability for a Harmonic perturbation, Interaction of an atom with radiation - Induced emission and absorption, The dipole approximation – selection rules. (Book 2, Section 10.3 to 10.5)

Module 3: Theory of scattering: (12L + 4T)
Scattering cross section, scattering amplitude of spinless particles – scattering amplitude and differential cross section- The Born approximation - Method of partial waves for elastic scattering, phase shifts, Optical theorem, The Born approximation (Book 2, Section 11.1 to 11.5)

Module 4: Relativistic Quantum Mechanics, Quantization of Fields: **(16L+5T)**
Early developments, the Klein-Gordon equation - charge and current densities - The Dirac equation- Dirac matrices- solution of free particle Dirac equation- spin of the electron- Equation of continuity- Hole theory- Dirac equation with potentials- Spin orbit

coupling - Covariance of Dirac equation - The Weyl equation for the neutrino.The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrödinger wave field for bosons and fermions.
(Book 3 – Relevant sections of chapter 10,11)

Books for study

1 David J. Griffiths, Darrell F. Schroeter - Introduction to Quantum Mechanics (3rd Edition, 2018, Cambridge University Press
2 Nouredine Zettili, Quantum Mechanics – Concepts and Applications (2nd Edition, 2004, John Wiley & Sons)
3 V. K. Thankappan , Quantum Mechanics (5th Edition, 2019, New Age Publishers)

References:

1 Franz Schwabl - Quantum mechanics (2007, Springer)
2 J. J. Sakurai, Modern Quantum Mechanics (Edn.2) : Pearson Education
3 R. Shankar - Principles of quantum mechanics (1994, Plenum Press)
4 A. F. J. Levi - Applied quantum mechanics (2006, Cambridge University Press
5 L..I.Schiff -Quantum Mechanics (1968, McGraw Hill)
6 P.M.Mathews and K.Venkatesan : “A Textbook of Quantum Mechanics" (Tata McGraw Hill)
7 James D Bjorken, Sidney D. Drell - Relativistic Quantum Mechanics (1998, McGraw-Hill Science_Engineering_Math)

MSPHN03C14: CONDENSED MATTER PHYSICS

(Contact hours -72 hrs (54 Lectures+ 18 Tutorials)

Course objectives:
Condensed matter physics use the well-established laws of microscopic physics to predict the collective and structural properties of matter. It is a science geared to technological development and is one of the most important areas of research in the recent times. Objectives of this course is to make students familiar with structures having regular and irregular arrangement of atoms, their bonding, lattice dynamics etc. They can also study the electric and magnetic properties of matter applying statistical mechanics and quantum mechanics. It also enables the students to know about area of superconductivity.

Module 1 (10L+3T):
Bragg law - Scattered wave amplitude - Brillouin Zones - Fourier analysis of the basis. Vibrations of crystals with monatomic and diatomic basis - Quantization of elastic waves -phonon momentum – Phonon heat capacity (Chapters 2, 4 & 5 of Book 1)

Module 2 (20L+8T):
Energy levels in 1D - Effect of temperature on Fermi- Dirac distribution - Free electron gas in three dimension - Heat capacity of electron gas - Electrical conductivity and Ohm's law – Hall effect -Thermal conductivity of metals. Nearly free-electron model – Bloch functions - Kronig- Penny model - Wave equation of electron in a periodic potential. Band gap - equations of motion - Intrinsic carrier concentration - Impurity conductivity - Calculation of energy bands (Wigner Seitz method) (Chapters6, 7, 8 & 9 of Book 1)

Module 3 (10L+3T):
Magnetic properties of materials: Langevin classical theory of diamagnetism, Langevin classical theory of paramagnetism, Fundamentals of quantum theory of paramagnetism, Ferromagnetism, The Weiss molecular field, Temperature dependence of spontaneous magnetisation, Ferromagnetic domains. (Chapters 16 of Book 2)

Module 4 (14L+4T):
Superconductivity – Introduction, Sources of Superconductivity, Response of Magnetic Field, The Meissner Effect, Thermodynamics or Superconducting Transform, Origin of Energy Gap, Isotope Effect, London Equations, London Penetration Depth, Coherence length, Elements of BCS Theory, Flux Quantization, Normal Tunneling and Josephson Effect, High Temperature Superconductivity. (Chapters 17 of Book 2).

Tutorial Suggestions:
Problems in chapter 2 of book 1 and in chapter 9, 10, 13, 16, 17 of Book 2.

Textbooks

1. C. Kittel-Introduction to Solid State Physics-VII Edition –John Wiley & Sons.
2. M. A. Wahab –Solid State Physics-Structure and Properties of Materials- Narosa Pub.

References
1. A. J. Dekker, Solid State Physics, Macmillan
2. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Cenage I Edition (2003).
2. Azaroff. V, Introduction to Solids, TMH
3. Omar Ali, Elementary Solid-State Physics, Addison Wesley.
4. J. S. Blakemore, Solid State Physics, Cambridge University Press.
5. S. O. Pillai, Solid State Physics, New Age International Publishers.
6. H. C. Gupta, Solid State Physics, Vikas Publishing
7. V.S Muraleedharan & A Subramania, Nano Science & Technology, Ane Books Pvt Ltd,2009.
8. Bharat Bhushan (Ed), Hand book of Nano Technology, Springer 2003
9. Gouzhong Cao, Nano structure and Nano materials: Synthesis, Properties and applications, Imperial college press, 2004.
10. NPTEL, Lectures on Solid State Physics by Nirmal Ganguly (NOC: Solid State Physics) ISER Bhopal. https://archive.nptel.ac.in

MSPHN03C15: Nuclear & Particle Physics (4C)
(Contact hours-72 hrs; 54 Lectures + 18 Tutorials)

Course Description:

The course aims to develop an understanding of advanced nuclear physics with the underlying quantum mechanical principles. Also, the students can get the idea of different types of nuclear radiation and their properties. The course provides the details of different elementary particles and its properties. In short, the course provides a good platform to carry forward the studies to higher levels.

Course Outcomes:

After completing this course, the students should be able to:

C01: Describe the basic properties of the nuclear force. (Module 1).
C02: Explain the nucleon-nucleon scattering and its underlying principles. (Module 1).
C03: Review the different nuclear models and nuclear reactions. (Module 2).
C04: Discuss nuclear fission and its applications. (Module 2).
C05: Describe different nuclear decays and explains the decay processes with theory. (Module 3).
C06: Review the conservation laws governing interactions involving elementary particles and discuss its internal structure. (Module 4).

Module 1: Nuclear Properties (14 L + 6 T)
Nuclear size, Techniques for determining size, Nuclear binding energy, Semiempirical mass formula, Nuclear angular momentum and parity, electromagnetic moments, Shapes and quadrupole moment. Nuclear two body problem: The deuteron, Wave function, Spin and Parity, Magnetic dipole and electric quadrupole moment, Low energy Nucleon-nucleon scattering, Partial wave analysis of n-p scattering, determination of phase shift, Analysis at high energy, p-p and n-p interactions, Properties of nuclear force, Exchange force model, Yukawa hypothesis. (Book 1: Chapter 3 & 4)

Module 2: Nuclear models and Reactions (12 L + 4 T)
Liquid drop model and drawbacks, Fermi gas model, Experimental evidence for magic numbers, shell model, spin-orbit potential, Magnetic dipole and electric quadrupole moment, valance nucleons, success of shell model, Even-Z, Even-N nuclei and collective structure. Nuclear reactions: Types of reactions and conservation laws, Kinematics of reactions, Scattering and reaction cross sections, compound nuclear reactions, direct reactions, resonant reactions. Nuclear fission: Characteristics of fission, energy in fission, controlled fission reactions, fission reactors. (Book 1: Chapter 5 ,12 & 14)

Module 3 Nuclear decays (14 L + 4 T)
Theory of Alpha decay, angular momentum and parity. Energy release in beta decay, Fermi theory of beta decay, the classical experimental tests of Fermi theory, angular momentum and parity selection rules, non-conservation of parity. Energetics of Gamma decay, angular momentum and parity selection rules. (Book 1: Chapter 8 , 9 & 10)

Module 4: Particle Physics (14 L + 4 T)
Four basic forces - Gravitational, Electromagnetic, Weak and Strong, Classification of particles, Yukawa's theory, Conservation of energy and masses, Electric charges, Conservation of linear and angular momentum, Baryon and lepton numbers, Conservation of strangeness, Conservation of isospin and its components, Conservation of parity, Charge conjugation, CP violation, time reversal and CPT theorem.
The Sakata model, SU (3), The eight-fold way, Gell-Mann and Okubo mass formula, Quarks and quark model, Confined quarks, Experimental evidence, Colored quarks. (Book 1: Chapter 17; Book 3: Chapter 6, 7, 9,10)

Book for Study:
1. Introductory Nuclear Physics, An Indian adaptation (3rd Edition), Kenneth S. Krane, Wiley (2022) .
2. Introduction to Nuclear Physics (1st Edition), Harald A. Enge, Addison Wesley (1996).
3. The particle hunters (2nd Revised Edition), Y. Neeman and Y. Kirsh, Cambridge University Press (1996)

Reference Books:
1. Concepts of Nuclear Physics, B. L. Cohen, McGraw-Hill Inc., US (1971).
2. Nuclear Physics: Theory and Experiment, R. R. Roy and B.P. Nigam, New age publishers (1996).
3. Theoretical Nuclear Physics, J. M. Blatt and V. F. Weisskopf, Springer- Verlag New York (1979).
4. An Introduction to Nuclear Physics (2nd Edition), S. B. Patel, New Age International (2011).
5. Nuclei and Particles, E. Segre, Benjamin (1967).

MSPHN03C16 – Practical III – Advanced and Computational Physics Laboratory

(At least 12 experiments should be done by choosing at least 6 experiments from cluster I and 6 experiments from cluster II)

Course Objectives

This course is designed to provide students with hands-on experience and practical training in various advanced experimental techniques and methods used in physics, nano sciences and computational physics. It applies concepts and principles learned in theoretical physics and electronics courses to design and conduct experiments.

Course Outcomes

C01: Acquire skills in setting up and conducting physics experiments using various advanced scientific instruments.
C02: Develop skills in synthcising
C03:
C04: Develop skills in collecting and analysing experimental data.
C05: Improve scientific writing skills to present experimental results in a clear and concise manner.
C06: Encourage critical analysis of experimental results and drawing valid conclusions.

Cluster I

(At least 6 experiments should be done)

1. Measurement of resistance of a thin film using Lock-in amplifier-extraction of small signal from high noise.
2. I-V Characteristics of 1D materials
3. I-V characteristics of thin film-distinguish between metallic material and insulating material
4. Hall effect measurement on thin film.
5. Planar Hall effect (PHE) measurements on magnetic nanofilms
6. AC Magneto-Optic Kerr effect- Hysteresis of thin films/single crystals.
7. DC Magneto-Optic Kerr effect- Hysteresis of thin films/single crystals
8. Magneto-Optic Faraday effect- Faraday rotations.
9. Polarisation by reflection-Determination of Brewster's angle of Glass
10. Expansion of crystal – By optical interference method.

11 Photoelectric cell – Study of elliptically polarized light using deadbeat galvanometer, quarter wave plate, and Nicol prism.
12 Interfacing stepper motor with PC using microcontrollers Arduino and standard controllers
13 Interfacing measurement equipment with PC using python/LabVIEW/ Node-Red
14 Controlling the temperature of a heating element using temperature sensor and Arduino/python (PWM or DC via PID control)
15 Solar cell – Spectral response and I-V characteristics.
16 LED characteristics – Determination of wavelength of emission, current-voltage characteristics and variation with temperature, variation of output power with applied voltage etc.
17 Laser intensity profile using photo diode and Laser spectra using spectrometer.
18 Measuring the absorption spectrum of nanoparticles/films using UV-VIS spectrometer.
19 Determination of energy Bandgap of semiconductor by UV spectroscopy
20 Determination of the particle size of the given materials using He-Ne LASER.
21 Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-Vis spectrophotometer.

22 XRD data analysis : Determination of crystallite size and lattice constant
23 TEM Data analysis-Image J.
24 XPS Data analysis.
25 SEM Data analysis-Surface roughness.
26 Determination of band gap energy in silicon and germanium
27 Four probe method – To study the bulk resistance and the band gap energy of the given semiconductor.
28 To determine the Band-Gap of given Semiconductor using Four Probe Method from Liquid Nitrogen Temp to Room Temperature.

29 Thin films – To determine the electrical conductivity, reflectivity, sheet resistance and refractive index

30 Synthesis of any nanoparticle by Chemical (Chemical reduction/Sol-gel/coprecipitation) method and their characterization by UV-VIS/FTIR

31 Fabrication of semiconductor thin film coatings using spin coating technique and characterisation

32 Photoelectric effect – Electronic charge and work function of metals.

References:

1 B.D. Cullity, Elements of X-ray diffraction, Addison Wesley Publishing company, Massachusetts, USA., 1978.
2 C.Suryanarayana, M.G. Norton, X-ray Diffraction A Practical Approach, Plenum Press, New york, 1998.
3 M. De Graef, Introduction to Conventional Transmission Electron Microscopy, Cambridge university Press, United kingdom, 2003.

4 C.R. Brundle, C.A.E. Jr., S. Wilson, Encyclopedia of materials characterization, Reed Publishing, USA, 1992.
5 Worsnop Flint – Advanced Practical Physics – Methuen & Co.

Cluster II

(At least 6 experiments should be done)

1 Band structure calculation of graphene using Quantum Espresso.
2 Write a program to generate random numbers using a mid-square method and to simulate random walk using these random numbers.
3 Write a program for generating square wave, triangular wave, and sawtooth wave using the Fourier technique.
4 Write a program to interpolate the value of a function using Lagrange's interpolating polynomials.
5 Write a program to plot the Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distributions. Prove the equipartition theorem, Stefan-Boltzmann law, and Wein's displacement law.
6 Write a program to study the trajectory of an ion in the Cyclotron Accelerator.
7 The solution of Transcendental Equation by Bisection Method and Newton's Method.
8 Numerical Solution to PDE - Stability and Convergence.
9 To study the numerical convergence and error analysis of non-linear equations using Newton-Raphson method.
10 Perform numerical integration on 1-D function using Trapezoid rule and Simpson rules.
11 To study the path of the projectile with and without air drag using Feynman-Newton method.
12 To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
13 Find out equilibrium bond length and ground state energy of Hydrogen molecules using First Principle methods.
14 Using Tight binding model, determine the band structure of graphene numerically.
15 Compute and analyse the electronic structure of semiconductors such as Si and Ge.
16 Compute and analyse the electronic structure of metals such as Au and Pt.
17 Electronic structure of graphene using density functional calculations.
18 Write a program to study the time evolution of a gaussian wave packet in infinite square well potential.

References:

1 Computational Physics, Problem Solving with Computers, Rubin H. Landau, Manuel J. P´aez and Cristian C. Bordeianu, John Wiley, and Sons, Inc.
2 Michael T. Heath: Scientific computing. An introductory survey, from McGraw-Hill.
3 Learning Scientific Programming with Python by Christian Hill published in 2015 by Cambridge University Press.
4 Tao Pang, an Introduction to Computational Physics (Cambridge University Press) 2nd edition, 2006.
5 J. P. Boyd, Chebyshev and Fourier Spectral Methods, Dover, 2001.
6 S. E. Koonin, Computational Physics, Westview, 1990.
7 P. L. Devries, J. E. Hasbun, A First Course in Computational Physics, Jones & Bartlett, 2011.
8 H. Gould, J. Tobochnik, W. Christian, An Introduction to Computer Simulation Methods: Applications to Physical Systems, Pearson, Addison-Wesley, 2007.
9 Steven H. Strogatz, Nonlinear dynamics and chaos with student solutions manual: With applications to physics, biology, chemistry, and engineering, CRC press, 2018.
10 The Nature of Mathematical Modelling, N. Gershenfeld, Cambridge University Press.
11 Press et. al, Numerical Recipes.
12 Effective Computation in Physics, Kathryn Huff and Anthony Scopatz, O'Reilly Media, Inc.
13 Computational Physics, N.J. Giordano, 1997, Prentice-Hall.
14 Physics by Computer, W. Kinzel & G. Reents, 1998, Springer-Verlag.
15 Introducing Python: Modern Computing in Simple Packages, B. Lubanovic, 2015, O'Reilly Media, Inc.
16 Python for Data Analysis, Wes McKinney, 2013, O'Reilly Media, Inc.
17 Python and Matplotlib Essentials for scientists and engineers, Matt A. Wood, 2015, Morgan & Claypool Publishers.

Open Elective Courses

MSPHN03O01: Machine Learning and Data Science

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides a comprehensive introduction to the principles and techniques of machine learning and data science. Students will learn about various machine learning algorithms, including supervised and unsupervised learning methods, and their applications in data analysis, pattern recognition, and decision-making. The course covers topics such as data preprocessing, feature engineering, model evaluation, and deployment. Emphasis is placed on hands-on experience with real-world datasets and the implementation of machine learning models using programming languages like Python.

Course Learning Outcomes:

CS01: Understand fundamental machine learning and data science concepts and principles.

CS02: Preprocess and engineer features for machine learning tasks.

CS03: Apply and implement supervised and unsupervised machine learning algorithms.

CS04: Evaluate and tune machine learning models using appropriate metrics and techniques.

CS05: Develop and deploy machine learning solutions for real-world data science problems using Python and associated libraries.

Module 1: Introduction to Machine Learning and Data Science (14 hours lecture, 6 hours tutorial)

- Overview of machine learning and data science
- Types of machine learning (supervised, unsupervised, reinforcement learning)
- Applications of machine learning and data science
- Python libraries for machine learning and data science (scikit-learn, TensorFlow, Keras, pandas, NumPy)
- Data exploration and visualisation techniques
- Working with structured and unstructured data

Module 2: Data Preprocessing, Feature Engineering, and Supervised Learning (18 hours lecture, 7 hours tutorial)

- Data cleaning and handling missing values
- Feature scaling and normalisation
- Dimensionality reduction techniques (PCA, LDA)
- Feature selection and extraction methods
- Linear and logistic regression
- Decision trees and ensemble methods (random forests, boosting)
- Support vector machines (SVMs)
- Artificial neural networks and deep learning
- Natural language processing (NLP) and text mining
- Computer vision and image processing

Module 3: Unsupervised Learning, Model Evaluation, and Data Science Applications (16 hours lecture, 6 hours tutorial)

- Clustering algorithms (k-means, hierarchical, DBSCAN)
- Dimensionality reduction techniques (PCA, t-SNE)
- Model evaluation and performance metrics
- Cross-validation and hyperparameter tuning
- Anomaly detection and outlier analysis
- Recommender systems and collaborative filtering
- Time series analysis and forecasting

Module 4: Data Science Project and Deployment (16 hours lecture, 6 hours tutorial)

- Data science project lifecycle and methodologies
- Data collection and integration from various sources
- Data governance and ethical considerations
- Model deployment and monitoring
- Cloud-based data science platforms and services
- Communicating and presenting data science findings

Textbook:

1 "Introduction to Machine Learning" by Ethem Alpaydin, MIT Press, 4th edition, 2020.

2 "Data Science from Scratch" by J. Grus, O'Reilly Media, 2019.

References:

1 "Pattern Recognition and Machine Learning" by C.M. Bishop, Springer, 2006.

2 "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by A. Geron, O'Reilly Media, 2019.

3 "Python Data Science Handbook" by J. VanderPlas, O'Reilly Media, 2016.

4 "The Elements of Statistical Learning" by T. Hastie, R. Tibshirani, and J. Friedman, Springer, 2009.

MSPHN03O02: Radiation Physics

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Objectives

C01: Understand different types of quantities and units for measurement of radiation

CO2: Understand various interaction mechanisms of radiation with matter

CO3: Understand radiation detection and measurement techniques and develop knowledge on different types of devices used.

CO4: Understand the principles of radiation protection

Module 1: Radiation Quantities and Units (12L + 4T)

Exposure-roentgen, Radiation Fluence, Flux, and Energy Fluence, Kerma Absorbed Dose: Rad or Gray, Roentgen-to-rad Conversion Factor , Relative Biological Effectiveness, Equivalent Dose and Effective Dose **(Chapter 10)**

Module 2: Interaction of Radiation with Matter (14L + 4T)

Attenuation, Coherent Scattering, Photoelectric Absorption, Compton Scattering, Pair Production, Relative Importance of Attenuation Process, Particle Interactions **(Chapter 11)**

Module 3: Radiation Detection and Measurements (14L + 5T)

Radiation Detection Principle, Types of Detectors and Efficiency, Gas-filled Chamber Detector, Practical Dosimeters, Solid State Detectors, Area Monitoring and Survey metres **(Chapter 12)**

Module 4: Principles of Radiation Protection (14L + 5T)

Sources of Radiation, Biological Effects of Radiation, Radiation Hazards Evaluation and Control, External and Internal Hazards, Personnel Monitoring Systems **(Chapter 28)** [Topics Workload, Use Factor and Occupancy Factor, Regulations in India are excluded from the syllabus]

Book for Study

1. Basic Radiological Physics- Kuppusamy Thayalan (2nd Edition), Jaypee Brothers Medical Publishers Pvt Ltd, New Delhi

MSPHN03O03: Environmental Physics and Earth Sciences

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course explores the intersection of physics with environmental science and earth science, focusing on understanding the physical processes that shape the environment and Earth's systems. Through theoretical concepts, laboratory experiments, and case studies, students will gain insights into topics such as atmospheric physics, climate dynamics, geophysics, and environmental monitoring.

Course Objectives:
C01: To comprehend the physical principles governing environmental processes and Earth's systems.
C02: To analyse the impact of human activities on the environment and climate.
C03: To explore methods for environmental monitoring and data analysis.
C04: To understand the role of physics in addressing environmental challenges and sustainability.

Module 1: Atmospheric Physics and Climate Dynamics
Introduction to atmospheric physics: composition, structure, and dynamics of the atmosphere - Energy balance and radiative transfer in the atmosphere - Climate dynamics: greenhouse effect, global warming, and climate change - Atmospheric circulation patterns: Hadley cells, jet streams, and monsoons - Indian monsoon: mechanisms, variability, and impacts.

Textbook

1. "Introduction to Atmospheric Physics" by D. J. Andrews

Reference Books
1. "Climate Dynamics" by Barry Saltzman
2. "Monsoon Meteorology" by C. P. Chang et al.

Module 2: Geophysics and Earth Systems
Fundamentals of geophysics: Earth's structure, seismic waves, and plate tectonics - Geophysical exploration techniques: seismic reflection, gravity, and magnetic methods - Earthquake dynamics: causes, mechanisms, and effects - Volcanic processes: eruptions, magma dynamics, and volcanic hazards - Tsunamis: generation, propagation, and impact assessment.

Textbook
1. "Introduction to Geophysics" by William Lowrie

Reference Books

1 "Solid Earth Geophysics" by C. M. R. Fowler
2 "Earthquake Seismology" by Haijiang Zhang et al.

Module 3: Environmental Monitoring and Data Analysis

Principles of environmental monitoring: air quality, water quality, and soil pollution - Measurement techniques: remote sensing, GIS, and sensor networks - Data analysis methods: statistical analysis, time series analysis, and spatial modelling - Case studies: environmental impact assessment, pollution mapping, and risk analysis - Role of citizen science in environmental monitoring.

Textbook

1 "Environmental Monitoring Handbook" by R. K. Trivedy and K. D. Goel

Reference Books

1 "Remote Sensing and GIS for Environmental Scientists" by Abdur Rahman et al.
2 "Introduction to Environmental Data Analysis" by Richard O. Gilbert

Module 4: Environmental Challenges and Sustainability

Major environmental challenges: climate change, pollution, deforestation, and loss of biodiversity - Sustainable development goals (SDGs) and environmental sustainability - Renewable energy resources: solar, wind, hydro, and biomass - Environmental policies and regulations: national and international frameworks - Role of physics in addressing environmental challenges: mitigation strategies and technological innovations.

Textbook

1 "Environmental Science and Engineering" by J. Glynn Henry et al.

Reference Books

1 "Sustainability Science: A Multidisciplinary Approach" by Hiroshi Komiyama et al.
2 "Physics for Future Presidents: The Science Behind the Headlines" by Richard A. Muller

MSPHN03O04: Physics in Disaster Management: Understanding and Mitigating Natural Hazards

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This advanced course explores the intricate relationship between physics and disaster management, focusing on the underlying physical principles governing natural hazards and their mitigation strategies. Through theoretical concepts and real-world case studies, students will delve into the physics behind various natural phenomena such as earthquakes, tsunamis, cyclones, and floods. They will learn how to apply physics-based approaches to assess risks, develop effective disaster preparedness plans, and implement sustainable mitigation measures.

Course Objectives:

C01: To understand the fundamental physics behind natural hazards and their impact on human societies.
C02: To analyse the complex interactions between natural processes and physical laws governing the behaviour of Earth systems.
C03: To explore advanced physics-based methodologies for disaster risk assessment, mitigation, and response.
C04: To develop critical thinking skills and practical expertise in applying physics principles to address real-world disaster management challenges.

Module 1: Fundamentals of Natural Hazards: A Physics Perspective

- Introduction to natural hazards: Understanding the physics behind earthquakes, tsunamis, cyclones, and floods.
- Seismic waves and earthquake dynamics: Exploring the propagation of seismic waves and the rupture mechanics of fault lines.
- Tsunami generation and propagation: Investigating the physical mechanisms driving the formation and spread of tsunamis.
- Atmospheric physics of cyclones: Unravelling the dynamics of tropical cyclones and their impact on weather patterns.
- Hydrodynamics of floods: Analysing the physics of riverine and coastal flooding and its implications for disaster management.

Textbook:

1 "Physics of Natural Disasters" by Devendra Lal and Vinod K. Gaur

Reference Books:

1 "Introduction to Geophysics" by P. M. S. Blackett

2 "Atmospheric Science: An Introductory Survey" by John M. Wallace and Peter V. Hobbs

Module 2: Physics-Based Risk Assessment and Hazard Mapping

- Probabilistic seismic hazard analysis (PSHA): Applying statistical methods and physics-based models to assess earthquake risks.
- Tsunami modelling and inundation mapping: Utilising numerical simulations to predict tsunami behaviour and coastal inundation.
- Cyclone risk assessment and wind engineering: Integrating physics principles with engineering techniques to evaluate cyclone impacts on infrastructure.
- Flood risk mapping and hydrological modelling: Employing physics-based models to analyse flood dynamics and develop flood hazard maps.

Textbook:

1 "Physics-Based Methods for Natural Hazard Assessment and Management" by John P. LaMoreaux and D. R. Tanner

Reference Books:

1 "Seismic Hazard and Risk Analysis" by Robin K. McGuire
2 "Tsunami: The Underrated Hazard" by Edward Bryant

Module 3: Physics-Informed Disaster Preparedness and Mitigation Strategies

- Earthquake-resistant building design: Integrating principles of structural mechanics with seismic engineering to develop resilient infrastructure.
- Tsunami early warning systems: Designing and implementing physics-based detection and alert systems for coastal communities.
- Cyclone-resistant construction techniques: Utilising materials science and fluid dynamics to build structures capable of withstanding extreme winds.
- Floodplain management and disaster resilience: Employing physics-based approaches to develop flood control measures and land use policies.

Textbook:

1 "Physics-Informed Disaster Management and Mitigation" by M. R. Reddy and R. V. Rajakumar

Reference Books:

1 "Earthquake-Resistant Design Concepts: An Introduction to the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures" by U.S. Geological Survey

2. "Tsunami Warning and Preparedness: An Assessment of the U.S. Tsunami Program and the Nation's Preparedness Efforts" by National Research Council

Module 4: Physics-Led Disaster Response and Recovery Strategies

- Search and rescue operations: Applying principles of mechanics and thermodynamics to optimise search and rescue efforts in disaster zones.
- Medical physics in disaster medicine: Utilising physics principles to provide emergency medical care and manage health-related challenges in post-disaster scenarios.
- Environmental physics in disaster recovery: Addressing environmental contamination and ecological restoration in the aftermath of disasters.
- Socio-economic impacts of natural disasters: Analysing the broader societal implications of disasters and exploring strategies for community resilience and recovery.

Textbook:

1. "Physics-Driven Disaster Response and Recovery" by S. K. Ghosh and A. K. Das

Reference Books:

1. "Disaster Response and Recovery: Principles and Practice" by Brenda D. Phillips
2. "Societal Impacts of Natural Disasters: A Case Study Approach to Understanding the Consequences" by Marie S. Shisler et al.

MSPHN03O05: Wonders of Quantum World

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description:

This course offers a comprehensive exploration of quantum mechanics and its applications, divided into four detailed modules. The first module, "The Quantum Story," covers the foundational developments in quantum theory, from Planck's quantum of action to Schrödinger's wave mechanics. The second module, "Quantum Interpretation and Quantum Debate," delves into the philosophical and scientific discussions surrounding quantum mechanics, including the Copenhagen Interpretation and the famous Bohr-Einstein debate. In the third module, "Quantum Nanostructures," students will learn about the preparation and properties of quantum dots, wells, and wires, as well as their applications in modern technology. The final module, "Quantum Computing," introduces the history and principles of quantum computing, including key concepts such as entanglement and quantum algorithms. Throughout the course, students will engage with seminal texts and cutting-edge research, preparing them for advanced study and innovation in the field of quantum science

Course Objectives:

C01: To understand the foundational principles and key developments in early quantum theory

C02: To critically analyse various interpretations and debates in quantum mechanics

C03: To understand the concepts of Quantum Nanostructures and apply this knowledge to practical devices

C04: To understand the basic principles of Quantum Computing

Module 1: The Quantum Story (14 L + 5 T)

Quantum of Action – Max Planck's discovery in 1900, Development of early quantum theory through Einstein's light quantum hypothesis, Bohr's quantum theory of atom, Dual wave particle hypothesis, Heisenberg's Matrix mechanics, puzzling phenomenon of electron spin, Pauli's exclusion principle, Schrodinger's wave mechanics (Book 1: Chapter 1 to 7)

Module 2: Quantum Interpretation and Quantum Debate (14 L +5 T)

Copenhagen Interpretation of quantum theory, Debates between Bohr, Heisenberg and Schrodinger on the reality of quantum jumps, Development of Uncertainty Principle, Bohr's como lecture in 1927, Bohr Einstein Debate, Einstein's thought experiments, EPR Paradox, Spin system and EPR argument, Bell's inequality, Schrodinger's cat paradox, Dirac's relativistic quantum theory (Book 1: Chapter 8 to 17)

Module 3: Quantum Nanostructures (14 L + 4 T)

Preparation of quantum nanostructures, quantum dots, quantum wells and quantum wires, Size and dimensionality effects, Excitons, single electron tunnelling, Infrared detectors, quantum dot lasers, superconductivity (Book 2: Chapter 9 – Quantum Wells, Wires and Dots)

Module 4: Quantum Computing (12 L + 4T)

The history of analytical engine, Turing's universal machine, Bits and Bytes, Gated Communities, Algorithm – speaking to the computer, Quantum strangeness – Entanglement, Quantum Algorithm, Quantum hardware (Book 3: Chapter 1 -6)

Books for Study

1 The quantum story- A history in 40 moments by Jim Baggot – Oxford University Press
2 Introduction to Nanotechnology – Charles P Poole, Frank J Owens – John Wiley & Sons
3 Quantum Computing – Brian Clegg

Reference Books

1 Quantum Revolution I – The breakthrough -G Venkataraman – Universities Press
2 Quantum Revolution III – What is reality? – G Venkataraman – Universities Press
3 Modern Physics, 2ndEdn. – Kenneth S. Krane – John Wiley & sons
4 Concepts of Modern Physics ,6thEdn–Arthur Beiser
5 Introduction to Quantum Mechanics, David J. Griffiths, Darrell F. Schroeter 3rd Edition, 2018, Cambridge University Press)
6 The quantum Age – Brian Clegg
7 Nano The Essentials by T Pradeep, Tata McGraw Hill, 2007
8 Approaching Quantum Computing – Dan C Marinescu, Gabriela M Marinescu – Pearson Education.

SYLLABUS

SEMESTER-IV

Elective Courses

A: Elective I

MSPHN04E01: Computational Physics

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides an in-depth understanding of computational techniques and their applications in solving complex physical problems. Students will learn various numerical methods, programming techniques, and computational tools used in modern physics research. The course emphasises the practical implementation of computational methods and their applications in diverse areas of physics.

Course Learning Outcomes:

CS01: Understand and apply various numerical methods and algorithms for solving complex physical problems.

CS02: Develop and implement computational programs using programming languages such as Python or C++ to solve physics problems.

CS03: Analyse and interpret computational results, including data visualisation and error analysis.

CS04: Utilise advanced computational techniques, such as Monte Carlo methods, molecular dynamics simulations, and finite element methods, in solving problems in specific areas of physics.

CS05: Develop computational skills and problem-solving abilities to tackle interdisciplinary research problems at the intersection of physics, mathematics, and computer science.

Module 1: Introduction to Computational Physics (13 hours lecture, 4 hours tutorial)

- Overview of computational physics and its importance in modern research
- Introduction to numerical methods and algorithms
- Programming languages for scientific computing (Python, C++, etc.)

- Basic data structures and algorithms
- Error analysis and numerical precision

Module 2: Numerical Methods for Ordinary and Partial Differential Equations (14 hours lecture, 5 hours tutorial)

- Finite difference methods for ordinary differential equations (ODEs)
- Runge-Kutta methods for ODEs
- Finite difference methods for partial differential equations (PDEs)
- Finite element methods for PDEs
- Boundary value problems and their numerical solutions

Module 3: Monte Carlo Methods and Molecular Dynamics Simulations (14 hours lecture, 5 hours tutorial)

- Introduction to Monte Carlo methods
- Random number generation and sampling techniques
- Metropolis algorithm and its applications
- Molecular dynamics simulations
- Simulation of many-body systems
- Applications in statistical mechanics and condensed matter physics

Module 4: Advanced Computational Techniques and Applications (13 hours lecture, 4 hours tutorial)

- Spectral methods and fast Fourier transforms
- Computational fluid dynamics
- Computational electromagnetics
- Computational quantum mechanics
- High-performance computing and parallel programming
- Applications in astrophysics, biophysics, and other interdisciplinary fields

Textbooks:

1 "Computational Physics" by J.M. Thijssen, Cambridge University Press, 2007.
2 "Numerical Recipes: The Art of Scientific Computing" by W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Cambridge University Press, 3rd edition, 2007.

References:

1 "An Introduction to Computational Physics" by T. Pang, Cambridge University Press, 2006.

2 "Computational Physics" by D. P. Landau and K. Binder, Cambridge University Press, 2015.

3 "Computational Physics: Problem Solving with Python" by R.H. Landau, M.J. Paez, and C.C. Bordeianu, Wiley-VCH, 2015.

4 "Python for Computational Science and Engineering" by J.H. Carpenter and M.A. Revzen, CRC Press, 2022.

5 "Computational Physics" by M. Newman, CreateSpace Independent Publishing Platform, 2013.

MSPHN04E02: Microprocessors and Digital Signal Processing

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides a comprehensive understanding of microprocessor systems and digital signal processing techniques. It covers the architecture and instruction set of the Intel 8085 microprocessor, assembly language programming, memory and I/O interfacing, peripheral device control, and digital signal processing fundamentals. Additionally, it explores topics such as signal processing basics, transform domain analysis, frequency domain analysis, and digital filter design.

Course Learning Outcomes:

CO1: Describe the architecture and instruction set of the Intel 8085 microprocessor and perform basic operations using assembly language.

CO2: Apply the principles of microprocessor timings to create efficient assembly programs and understand the machine cycles and timing diagrams.

CO3: Interface memory and I/O devices with the 8085 microprocessor and utilise address decoding techniques for system design.

CO4: Design and develop applications using microcontrollers, particularly the 8051, and understand their internal architecture and stack operations.

CO5: Analyse discrete-time signals and systems using Z Transform, DTFT, and DFT, and design FIR and IIR filters for digital signal processing applications.

Module 1: Microprocessor and Assembly language programming (10 hours lecture, 5 hours tutorial)

- Instruction set of Intel 8085, Addressing modes,
- Examples of Assembly language programming
- Addition and subtraction of 1 byte and 2-byte numbers, BCD addition and subtraction, multiplication and division of 1 byte numbers,
- Sorting of 1-byte numbers, square root of a number,
- Stack and Subroutines (Book 1)

Module 2: Microprocessor timings (10 hours lecture, 3 hours tutorial)

Interfacing memory and I/O devices and Interrupts, Instruction cycles, machine cycles and timing diagrams, address space partitioning, interfacing, memory interfacing, I/O device interfacing, Address decoding using 74LS138, Data Transfer Schemes.

(Book 1 and 2)

Module 3: Peripheral devices and Interfacing (10 hours lecture, 5 hours tutorial)

Generation of control signals for memory and I/O devices, I/O ports, Programmable Peripheral Interface- Intel 8255, Programmable Interval Timer- Intel 8253, Programmable DMA controller- Intel 8257, Programmable Interrupt controller- Intel 8259, Programmable communication Interface Intel 8251, ADC interfacing - General idea with block diagram, 7 segment LED display interfacing – General idea of display and driver.

(book 1)

Microcontrollers:

Overview of microcontrollers, Architecture of 8051 Microcontroller, 8051 register and stack

(book 3)

Module 4: Digital Signal Processing (20 hours lecture, 7 hours tutorial)

Introduction to Signal Processing: [4L+1T]

Signals, Systems, Signal Processing, Basic signals, operations, and properties, System Properties, Impulse Response, convolution.

Transform domain analysis of discrete-time systems: [5L+2T]

Z Transform - Definition and properties, region of convergence, inverse Z transform, transfer function, poles and zeros, Sampling, Aliasing.

Frequency Domain Analysis of Discrete Time Signals: [5L+2T]

DTFT, Discrete Fourier Transform (DFT), Properties of DFT, Linear convolution using DFT. Fast Fourier Transform (FFT).

Digital Filters: [6L+2T]

FIR and IIR filters characteristics, FIR filters, Design of Linear phase FIR filters using different windows, Analog filter design using Butterworth and Chebyshev approximations.

(Book 4)

Textbooks:

1 Fundamentals of Microprocessors and Microcomputers– B. Ram – Dhanapati Rai.
2 Introduction to Microprocessors – A.P. Mathur (Tata-McGraw Hill).
3 Microcontrollers and embedded systems—Muhammed Ali Mazidi& Janice Guillespie Mazidi — PHI.
4 Proakis J.G. and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, (3e), PHI, 2007.

References:

1 Microprocessors – Architecture, Programming and Applications with 8085 - R.S.Gaonkar (Wiley Eastern).
2 Oppenheim A.V, Willsky A.S, Signals and Systems, (2e), PHI,2011.
3 Oppenheim A.V. and R.W. Schafer, Discrete time signal processing, (2e), Prentice-Hall, 2001.
4 Rabiner L.R and Gold D.J, Theory and Applications of Digital Signal Processing, (2e), Prentice Hall, 2007.
5 Digital Signal processing: S. Salivahanan, Tata McGraw Hill education (2011).

MSPHN04E03: Quantum Optics and Computing

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides an advanced understanding of the principles of quantum optics and their applications in quantum computing. Students will learn about the fundamental concepts of quantum mechanics, light-matter interactions, and quantum information theory. The course covers various topics such as quantum states, quantum measurements, entanglement, and quantum algorithms. It also explores the implementation of quantum computing using different physical systems, including trapped ions, superconducting circuits, and photonic systems.

Course Learning Outcomes:

CS01: Understand the fundamental principles of quantum mechanics and their applications in quantum optics and quantum computing.

CS02: Analyse and describe the quantum nature of light-matter interactions and their applications in quantum information processing.

CS03: Comprehend the concepts of quantum states, quantum measurements, and entanglement, and their roles in quantum computing.

CS04: Develop an understanding of quantum algorithms, quantum error correction, and quantum computational complexity.

CS05: Evaluate the implementation of quantum computing using different physical systems and their respective advantages and challenges.

Module 1: Introduction to Quantum Optics and Quantum Computing (12 hours lecture, 4 hours tutorial)

- Principles of quantum mechanics
- Quantization of the electromagnetic field
- Quantum states and quantum measurements
- Introduction to quantum computing and quantum information

Module 2: Light-Matter Interactions and Quantum States (14 hours lecture, 5 hours tutorial)

- Atom-field interactions and the Jaynes-Cummings model
- Coherent states and squeezed states
- Nonclassical states of light
- Quantum entanglement and Bell's inequalities

Module 3: Quantum Algorithms and Quantum Computational Complexity (14 hours lecture, 5 hours tutorial)

- Quantum circuits and quantum gates
- Quantum algorithms (Shor's algorithm, Grover's algorithm, etc.)
- Quantum error correction and fault-tolerance
- Quantum computational complexity and the quantum advantage

Module 4: Physical Implementations of Quantum Computing (14 hours lecture, 4 hours tutorial)

- Trapped ion quantum computing
- Superconducting circuit quantum computing
- Photonic quantum computing
- Other physical systems for quantum computing
- Challenges and future prospects

Textbooks:

1 "Quantum Optics" by M.O. Scully and M.S. Zubairy, Cambridge University Press, 1997.
2 "Quantum Computing: A Gentle Introduction" by M.A. Nielsen and I.L. Chuang, MIT Press, 2010.

References:

1 "Introduction to Quantum Optics: From the Semi-classical Approach to Quantized Light" by G. Grynberg, A. Aspect, and C. Fabre, Cambridge University Press, 2010.
2 "Quantum Computation and Quantum Information" by M.A. Nielsen and I.L. Chuang, Cambridge University Press, 2000.
3 "Quantum Computing: A Primer" by J.A. Jones, Wiley-VCH, 2022.

4 "Quantum Optics and Nanophotonics" by M.L. Brongersma and P.G. Kik, Cambridge University Press, 2022.

MSPHN04E04: Computational Materials Sciences

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Objectives:

The "Materials Science" course is designed to provide students with a comprehensive understanding of the fundamental principles governing the structure, properties, and behaviour of materials. It aims to equip students with the knowledge needed to analyse and solve materials-related problems in engineering and technology fields. The course objectives include:

1. **Understanding Materials Classification and Structures:** Introduce students to the classification of materials, including advanced materials, and the fundamental concepts of atomic structure and bonding. Emphasize the importance of crystalline structures and the role of imperfections in influencing material properties.
2. **Analysing Mechanical Properties and Failure Mechanisms:** Develop a thorough understanding of the mechanical properties of materials, the behaviour under stress, and the mechanisms that contribute to material strength. Explore the various modes of material failure, including fracture, fatigue, and creep, and the principles of fracture mechanics.
3. **Comprehending Phase Diagrams and Transformations:** Educate students on phase diagrams and phase transformations, including nucleation, growth kinetics, and microstructure development. Highlight the significance of phase equilibria and transformations in materials engineering.
4. **Exploring Advanced and Smart Materials:** Familiarize students with advanced materials, including ceramics, polymers, composites, and smart materials. Discuss the applications, properties, and societal impacts of these materials, along with an introduction to nanotechnology and sustainable materials.

Course Outcomes:

Upon successful completion of the "Materials Science" course, students will be able to:

1. **Classify and Describe Material Types:** Clearly classify materials and describe their atomic structures, bonding types, and crystalline arrangements. Understand and explain the significance of imperfections in solids and their impact on material properties.
2. **Evaluate Mechanical Behaviour:** Analyse and interpret stress-strain behaviour of materials. Evaluate the factors influencing elasticity, plasticity, hardness, toughness, and ductility. Understand the mechanisms of dislocation motion, strengthening, recovery, recrystallization, and grain growth.
3. **Interpret Phase Diagrams:** Utilize phase diagrams to determine phase equilibria and predict microstructure development. Apply concepts such as the lever rule, solubility limits, and phase transformations to real-world material engineering problems. Understand the kinetics of nucleation and growth and their role in phase transformations.

4 **Analyse Advanced Material Applications:** Explain the structure and properties of ceramics, polymers, and composites. Identify and analyse the applications and importance of smart materials and nanotechnology. Assess the environmental and societal implications of material choices, emphasizing sustainable and green engineering practices.

Module 1: Fundamentals of Materials Science (Duration: 15 Hours)

Introduction to Materials Science - Classification of Materials -Advanced Materials and Their Needs. The Structure of Crystalline Solids - Crystal Structures: Fundamental Concepts - Unit Cells and Metallic Crystal Structures - Density Computations and Atomic Packing Factors Polymorphism and Allotropy. Crystallographic Directions and Planes - Crystal Systems and Point Coordinates - Crystallographic Directions and Planes - Linear and Planar Densities - Imperfections in Solids - Point Defects, Vacancies, and Interstitials - Dislocations and Other Linear Defects - Grain Boundaries and Other Interfacial Defects

Module 2: Mechanical Properties and Failure (Duration: 18 Hours)

Mechanical Properties of Materials - Stress-Strain Behaviour -Elastic and Plastic Deformation - Hardness, Toughness, and Ductility. Dislocations and Strengthening Mechanisms - Dislocation Motion and Slip Systems - Mechanisms of Strengthening in Metals - Recovery, Recrystallization, and Grain Growth. Failure of Materials - Fundamentals of Fracture Mechanics - Types of Fracture: Ductile and Brittle -Fatigue: Cyclic Stresses and the S-N Curve - Creep: Time-Dependent Deformation.

Module 3: Phase Diagrams and Transformations (Duration: 12 Hours)

Phase Diagrams - Definitions and Basic Concepts - Solubility Limit and Phases - Unary and Binary Phase Diagrams - Lever Rule and Phase Equilibria - Phase Transformations - Nucleation and Growth Kinetics - Isothermal and Continuous Cooling Transformations - Development of Microstructure in Alloys.

Module 4: Advanced and Smart Materials (Duration: 15 Hours)

Introduction to Advanced Materials - Definition and Classification -Applications and Importance. Ceramics, Polymers, and Composites - Structure and Properties of Ceramics - Polymer Structures and Their Mechanical Properties - Composite Materials: Types and Applications. Smart Materials and Nanotechnology - Types of Smart Materials: Shape Memory Alloys, Piezoelectrics, Magnetostrictives - Properties and Applications of Smart Materials - Introduction to Nanomaterials and Nanotechnology. Environmental and Societal Issues - Environmental Impact and Recycling of Materials - Sustainable Materials and Green Engineering - Biodegradable and Bio-renewable Polymers.

Text for study:
'Materials Science and Engineering: An Introduction' by William D. Callister Jr. and David G. Rethwisch, John Wiley & Sons, Edition: 10th Edition (2020)

References:

- **"Introduction to Materials Science for Engineers" by James F. Shackelford,** Pearson, Edition: 9th Edition (2014)

- "The Science and Engineering of Materials" by Donald R. Askeland and Wendelin J. Wright, Cengage Learning, Eion: 7th Edition (2015)
- "Physical Metallurgy Principles" by Robert E. Reed-Hill and Reza Abbaschian, Cengage Learning, 4th Edition (2008)

- "Deformation and Fracture Mechanics of Engineering Materials" by Richard W. Hertzberg, Richard P. Vinci, and Jason L. Hertzberg, John Wiley & Sons, Edition: 5th Edition (2012)

- "Phase Transformations in Metals and Alloys" by David A. Porter and Kenneth E. Easterling, CRC Press, Edition: 3rd Edition (2009)

- "Materials Science and Engineering: A First Course" by V. Raghavan, Prentice Hall India, Edition: 6th Edition (2015)

MSPHN04E05: Quantum Field Theory

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: Quantum Field Theory (QFT) is a fundamental theoretical framework that combines classical field theory, quantum mechanics and special relativity. This course provides a comprehensive introduction to the principles and techniques of QFT, which are essential for understanding the behaviour of fundamental particles and interactions in the universe. This course will be helpful for students who are interested in high-energy physics and/or condensed matter theory in future.

Course Outcomes:

C01: To understand the quantization of fields and the significance of field operators.

C02: To explore the concept of symmetries and conservation laws in field theory.

C03: Derive the Feynman rules from a given Lagrangian and calculate cross sections and decay rates.

C04: Introduces the relativistic effects in quantum mechanics and learns to deal with large degrees of freedom.

C05: To study the interactions of scalar, fermionic and gauge fields.

C06: Understand Quantum Field Theory applications in various branches of physics.

Module 1: Canonical Quantization (16 L + 6 T)

- General Formulation. Conjugate Momentum and Quantization. Neutral Scalar
- Field. Commutation Relations, Normal Ordering, Bose Symmetry, Fock Space.
- Charged Scalar Field. U (1) Invariance, Charge Conservation, Particles and
- Antiparticles. Time Ordered Product, Feynman Propagator for Scalar Fields,
- Bose-Einstein Distribution, Propagators at Finite Temperature.

(Book 1: Chapter 1, Book 2: Chapter 3)

Module 2: Dirac Field (10 L + 4 T)

- The Dirac Equation, Relativistic Covariance. Anticommutators. Quantization of

- the Dirac Field, Electrons and Positrons. Connection between Spin and
- Statistics. Discrete Symmetries, Parity, Charge Conjugation, Time Reversal,
- CPT Theorem.

(Book 1: Chapter 3, Book 2: Chapter 4)

Module 3: Gauge Field (12 L + 4 T)

- Gauge Invariance and Gauge Fixing.
- Quantization of the Electromagnetic Field,
- Propagator, Vacuum Fluctuations. Wick's Theorem.
- Feynman Rules and Feynman Diagrams for Spinor Electrodynamics.

(Book 2: Chapter 8 & 9, Book 3: Chapter 3)

Module 4: Interacting Theory and Elementary Processes (16 L + 4 T)

- Lowest Order Cross-Section for Electron-Electron,
- Electron-Positron and Electron-Photon Scattering.
- Elementary Ideas on Radiative Corrections and Renormalization.

(Book 1: Chapter 5, Book 2: Chapter 12, Book 3: Chapter 9)

Textbooks:

1 An Introduction to Quantum Field Theory, M. E. Peskin and D. V. Schroeder, Westview Press, 1995.
2 A First Book of Quantum Field Theory, Amitabha Lahiri, Palash B. Pall, 2005, CRC Press.
3 Quantum Field Theory, L. H. Ryder, Cambridge University Press, 2008.

References:

1 Field Theory, A Modern Primer, P. Ramond, Benjamin, 1980.
2 The Quantum Theory of Fields, Vol I, S. Weinberg, Cambridge University Press, 1996.
3 Quantum Field Theory for the Gifted Amateur, Tom Lancaster, Stephen J. Blundell, Oxford University Press, 2014.
4 Quantum Field Theory - Prof. Dr. Prasanta Kumar Tripathy (Nptel Lectures).

B: Elective II

MSPHN04E06: Physics of Nano Systems

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides an in-depth understanding of the physical principles governing the behaviour of nanoscale systems. Students will learn about the unique properties of materials and phenomena that emerge at the nanoscale, as well as the theoretical and experimental techniques used to study and characterise these systems. The course covers topics such as quantum confinement effects, low-dimensional structures, nanomaterials, and their applications in various fields, including electronics, optoelectronics, energy, and biotechnology. Emphasis is placed on the interdisciplinary nature of nanoscience and the interplay between theory, computation, and experimentation.

Course Learning Outcomes:

CS01: Understand the fundamental physical principles governing the behaviour of nanoscale systems and the unique properties that emerge at the nanoscale.

CS02: Describe the quantum confinement effects and their manifestations in low-dimensional structures, such as quantum wells, quantum wires, and quantum dots.

CS03: Explain the different synthesis methods for the synthesis of Nanomaterials

CS04: Describe the various characterization techniques to understand the properties of nanomaterials.

Module 1: Introduction to nano systems (14 hours lecture, 4 hours tutorial)

- Introduction to nanoscale systems.
- Definition of nanoscale, Bulk Vs nanomaterials.
- Surface to volume ratio.
- Classification of nanostructures: Different dimensions (0-D, 1-D, 2-D and 3-D) and their realisations.
- Electrical, mechanical, magnetic and optical properties of nanomaterials.
- Nano magnetism.

Module 2: Quantum Confinement: size effects (12 hours lecture, 5 hours tutorial)

- Quantum size effects

- Quantum mechanics at the nanoscale
- Quantum confinement in one dimension (Quantum wells); in two dimension (Quantum wires); in three dimension (Quantum dots)
- Energy levels and wave functions for Quantum wells, wire and dots.
- Electric and magnetic transport phenomena at low dimensions.

Module 3: Synthesis of Nanomaterials (14 hours lecture, 5 hours tutorial)

- Top down and bottom-up methods
- Chemical and physical methods
- Sol-gel method, Co-precipitation method, Chemical reduction method, Hydrothermal method, Reverse micelle method, Micro-emulsion method, sono-chemical and solid-state method
- Methods of Thin Films deposition: Vacuum Evaporation: Resistive Heating, MBE, Electron Beam Evaporation and Pulsed Laser Deposition
- Sputtering: Glow Discharge, Radio Frequency and Magnetron Sputtering
- Chemical Methods: MOCVD, ALD, LCVD, PCVD and PECVD.

Module 4: Characterization Techniques of nanomaterials (14 hours lecture, 4 hours tutorial)

- X-ray Diffraction technique (XRD) - Crystallinity, structural analysis and particle/crystal size determination.
- Scanning electron microscopy (SEM) - morphology and grain size
- Transmission electron microscopy (TEM) - Morphology, particle size and electron diffraction, Selected area electron diffraction (SAED).
- Atomic force microscopy (AFM) - Surface imaging and roughness
- Scanning Tunnelling Microscopy (STM) - Surface imaging and roughness.

Textbooks:

4 "Solid State Physics: An Introduction" by P. Hofmann, Wiley-VCH, 2015.
5 "Introduction to Nanotechnology" by C.P. Poole Jr. and F.J. Owens, Wiley, 2003.
6 Nanomaterials - An Introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second edition 2013.
7 Chopra, K. L., Thin Film Phenomena, McGrow Hill, USA, 1969
8 In Situ Real-Time Characterization of Thin Films, Orlando Auciello and Alan R Krauss, Published under licence by IOP Publishing Ltd.

9 B.D. Cullity, Elements of X-ray diffraction, Addison Wesley Publishing company, Massachusetts, USA., 1978.
10 C.R. Brundle, C.A.E. Jr., S. Wilson, Encyclopedia of materials characterization, Reed Publishing, USA, 1992.

References:

5 "Nano: The Essentials" by T. Pradeep, McGraw-Hill Education, 2007.
6 "Nanotechnology: Principles and Practices" by S.K. Kulkarni, Springer, 2015.
7 "Quantum Phenomena in Clusters and Nanostructures" by S.N. Khanna and A.W. Castleman Jr., Springer, 2003.
8 "Nanostructures and Nanotechnology" by M.A. Reed and T. Lee, Cambridge University Press, 2011.
9 "Nanophysics and Nanotechnology" by E.L. Wolf, Wiley-VCH, 2006.

MSPHN04E07: Nano Optics

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides an in-depth understanding of the optical phenomena and principles at the nanoscale. Students will learn about the fundamental concepts of light-matter interactions, plasmonics, metamaterials, and nanophotonic devices. The course covers topics such as near-field optics, surface plasmon resonance, metallic and dielectric nanostructures, and their applications in various fields, including sensing, imaging, and optical information processing. Emphasis is placed on the theoretical and computational aspects of nano-optics, as well as the practical implementation and characterization of nanophotonic systems.

Course Learning Outcomes:

CS01: Understand the fundamental principles of light-matter interactions at the nanoscale and the unique optical properties of nanostructures.

CS02: Describe the theory and applications of surface plasmon resonance and plasmonic nanostructures.

CS03: Explain the principles and design of metamaterials and their potential applications in optics and photonics.

CS04: Analyze and model the optical response of metallic and dielectric nanostructures using computational techniques.

CS05: Design and characterise nanophotonic devices for various applications, such as sensing, imaging, and optical information processing.

CS06: Appreciate the interdisciplinary nature of nano-optics and its potential impact on various fields.

Module 1:Introduction to Nano Optics (12 hours lecture, 4 hours tutorial)

- Overview of nano optics and its importance
- Fundamental concepts of light-matter interactions at the nanoscale
- Near-field optics and evanescent waves
- Optical properties of nanostructures

Module 2: Plasmonics and Surface Plasmon Resonance (14 hours lecture, 5 hours tutorial)

- Introduction to plasmonics
- Surface plasmon polaritons and localised surface plasmons
- Metallic nanostructures and their optical properties
- Applications of plasmonics in sensing, imaging, and spectroscopy

Module 3: Metamaterials and Nanophotonic Devices (14 hours lecture, 5 hours tutorial)

- Principles of metamaterials and their design
- Negative refractive index and superlensing
- Cloaking and transformation optics
- Nanophotonic devices for sensing, imaging, and optical information processing

Module 4: Computational Nano Optics and Characterization Techniques (14 hours lecture, 4 hours tutorial)

- Finite-difference time-domain (FDTD) and finite element method (FEM) for nano optics
- Near-field scanning optical microscopy (NSOM)
- Electron energy loss spectroscopy (EELS) and cathodoluminescence
- Experimental techniques for characterising nanophotonic devices

Textbooks:

11 "Nano-Optics" by L. Novotny and B. Hecht, Cambridge University Press, 2012.

12 "Principles of Nano-Optics" by L. Novotny and B. Hecht, Cambridge University Press, 2006.

References:

10 "Plasmonics: Fundamentals and Applications" by S.A. Maier, Springer, 2007.

11 "Metamaterials: Theory, Design, and Applications" by T.J. Cui, D.R. Smith, and R. Liu, Springer, 2010.

12 "Nanophotonics" by M.L. Brongersma and P.G. Kik, Cambridge University Press, 2022.

13 "Surface Plasmon Nanophotonics" by M.L. Brongersma and P.G. Kik, Springer, 2007.

14 "Optical Metamaterials: Fundamentals and Applications" by W. Cai and V. Shalaev, Springer, 2010.

MSPHN04E08: Thin Films, Crystal Growth and Characterization

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides a comprehensive introduction to the principles and techniques of machine learning and data science. Students will learn about various machine learning algorithms, including supervised and unsupervised learning methods, and their applications in data analysis, pattern recognition, and decision-making. The course covers topics such as data preprocessing, feature engineering, model evaluation, and deployment. Emphasis is placed on hands-on experience with real-world datasets and the implementation of machine learning models using programming languages like Python.

Course Learning Outcomes:

CS01: Understand the physical principles governing biological systems at various scales, from molecules to cells and organisms.

CS02: Describe the structure and function of biomolecules, including proteins, nucleic acids, and membranes, and their role in biological processes.

CS03: Explain the principles and applications of various biophysical techniques, such as spectroscopy, microscopy, and diffraction methods, for studying biological systems.

CS04: Discuss the fundamental concepts and applications of bionanotechnology, including nanomaterials, nanodevices, and their applications in biotechnology and medicine.

CS05: Analyse and interpret experimental data related to biophysical and bionanotechnology studies.

CS06: Appreciate the interdisciplinary nature of biophysics and bionanotechnology and their potential impact on various fields.

Module 1: Crystal Growth (12 hours lecture, 4 hours tutorial)

- Basic concepts and experimental methods of crystal growth: nucleation phenomena,
- Mechanisms of growth, dislocations and crystal growth, crystal dissolution
- Phase equilibria, phase diagrams and material preparation, growth from solid –solid equilibria, liquid-solid equilibria, vapour-solid equilibria,

- Mono-component and multi-component techniques.
- Crystal characterization.

Module 2: Thin Film Growth (14 hours lecture, 5 hours tutorial)

- Methods of Preparation/Synthesis of Thin Films: Vacuum Evaporation: Resistive Heating, MBE, Electron Beam Evaporation and Pulsed Laser Deposition
- Sputtering: Glow Discharge, Radio Frequency and Magnetron Sputtering
- Chemical Methods: MOCVD, ALD, LCVD, PCVD and PECVD
- Spin coating-Spray Method: Spray Hydrolysis and Spray Pyrolysis
- Langmuir Blodgett Technique
- Sol-gel Deposition.

Module 3: Synthesis of Nanomaterials (14 hours lecture, 5 hours tutorial)

- Introduction to nanomaterials
- General methods of synthesis
- Chemical methods for the synthesis of Nanomaterials
- Sol-gel method, Co-precipitation method, Chemical reduction method
- Hydrothermal method, Micro-emulsion method
- Reverse micelle method, Solvo thermal method
- Sono chemical method and solid-state method.

Module 4: Characterisation (14 hours lecture, 4 hours tutorial)

- Thickness Measurements: Resistance, Capacitance, Microbalance, Quartz Crystal Thickness Monitor, Optical Absorption-reflection-transmission, Multiple Beam Interference, Interference Colour and Ellipsometry Methods.
- Scanning electron microscopy
- Atomic force microscopy
- XRD, and Focused ion beam machining,
- TEM, LEED, MEED, RHEED, XPS. Hall effect.

Textbooks:

1 "Crystal Growth for Beginners" by I.V. Markov and S. Stoyanov, World Scientific, 2003.
2 "Thin Film Materials: Stress, Defect Formation and Surface Evolution" by L.B. Freund and S. Suresh, Cambridge University Press, 2004.

3 "Epitaxial Growth of Complex Metal Oxides" by G. Koster, G. Rijnders, D.H.A. Blank, and H. Rogalla, Woodhead Publishing, 2012.

4 "Thin Film Processes" by J.L. Vossen and W. Kern, Academic Press, 1991.

5 "Introduction to Solid State Physics" by C. Kittel, Wiley, 2004.

6 "Characterization of Materials" by E.N. Kaufmann, Wiley, 2003.

7 "Growth of Crystals" by R. A. Laudise, Prentice-Hall, 1970.

8 "Hand Book of Crystal Growth" by D. T. J. Hurle (ed.), North Holland 1994.

9 "Thin Film Phenomena" by K. L. Chopra, McGrow Hill, USA, 1969.

10 "In Situ Real-Time Characterization of Thin Films" by Orlando Auciello and Alan R Krauss, Published under licence by IOP Publishing Ltd.

11 "Elements of X-ray diffraction" by B.D. Cullity, Addison Wesley Publishing company, Massachusetts, USA., 1978.

12 "Encyclopedia of materials characterization" by C.R. Brundle, C.A.E. Jr., S. Wilson, Reed Publishing, USA, 1992.

13 "The Chemistry of Nanomaterials: Synthesis, Properties and Applications" by A. Muller, A.K.Cheetham (Eds.), WILEY-VCH Verlag GmbH&Co.,Weinheim, 2004.

14 "Nanoparticles and Nanostructured Films Preparation, Characterization and Applications" by Janos H .Fendler (Editor), Wiley –VCH, 1998.

15 "Nanostructures and Nanomaterials: Synthesis, properties and applications" by G.Cao, Imperial College Press, 2004.

MSPHN04E09: Materials Science

Contact Hours: 72 hrs (54 Lectures + 18 Tutorials)

Course Objectives:

- To provide a comprehensive understanding of the fundamental concepts related to the structure of crystalline solids, including crystal systems, unit cells, and crystallographic directions and planes.
- To explore the differences between crystalline and non-crystalline materials, and the significance of polymorphism and allotropy.
- To understand the types and characteristics of imperfections in solids, such as point defects, dislocations, and grain boundaries.
- To learn the principles of diffusion in materials, including the mechanisms and factors influencing diffusion processes.
- To study the mechanisms of plastic deformation, including dislocation motion and slip systems in crystalline materials.
- To examine the fundamentals of fracture mechanics, fatigue, and creep behaviour in materials.
- To introduce phase diagrams and their significance in understanding phase equilibria and microstructure development in materials.
- To interpret binary phase diagrams and understand the development of microstructures in isomorphous and eutectic alloys.
- To address environmental and societal issues related to materials science and engineering, including recycling, biodegradable polymers, and sustainable materials.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Describe the Structure of Crystalline Solids:**
    - Identify and explain various crystal structures and unit cells.
    - Compute densities for different crystal structures and understand the concept of polymorphism and allotropy.
    - Use crystallographic notation to specify directions and planes in crystals.
2. **Analyse Imperfections and Diffusion Processes:**
    - Describe different types of imperfections in solids and their implications on material properties.
    - Explain diffusion mechanisms and apply Fick's laws to solve diffusion problems.
    - Utilize microscopy techniques to examine and characterize grain size and other microstructural features.
3. **Understand Dislocations and Strengthening Mechanisms:**
    - Explain the role of dislocations in plastic deformation and characterize different slip systems.
    - Discuss the processes of recovery, recrystallization, and grain growth and their effects on materials.
    - Analyse fracture mechanisms and factors affecting fatigue and creep behavior.
4. **Interpret Phase Diagrams and Microstructures:**
    - Interpret unary and binary phase diagrams and predict phase transformations.
    - Develop and analyse microstructures in isomorphous and eutectic alloy systems.

- Assess the mechanical properties of alloys based on their phase diagrams and microstructures.

5 **Evaluate Environmental and Societal Issues:**
- Discuss the importance of recycling and sustainable materials in materials science and engineering.
- Evaluate the environmental impact of materials and propose solutions involving biodegradable and bio-renewable polymers.

Through this holistic approach, the course aims to equip students with both theoretical knowledge and practical skills essential for advancing in the field of materials science and engineering.

Module 1
Introduction and Structure of Crystalline Solids

Classification of Materials - Advanced Materials - Modern Materials' Needs. The Structure of Crystalline Solids- Crystal Structures - Fundamental Concepts - Unit Cells - Metallic Crystal Structures - Density Computations - Polymorphism and Allotropy. Crystal Systems - Point Coordinates -Crystallographic Directions - Crystallographic Planes - Linear and Planar Densities - Close-Packed Crystal Structures. Crystalline and Non-crystalline Materials - Single Crystals - Polycrystalline Materials – Anisotropy. X-Ray Diffraction: Determination of Crystal Structures – Non-crystalline Solids.

Module 2
Imperfections in Solids and Diffusion

Point Defects - Vacancies and Self-Interstitials - Impurities in Solids - Specification of Composition -Miscellaneous Imperfections - Dislocations—Linear Defects - Interfacial Defects - Bulk or Volume Defects - Atomic Vibrations Microscopic Examination - Basic Concepts of Microscopy - Microscopic Techniques - Grain-Size Determination. Diffusion - Diffusion Mechanisms- Fick's First Law -Fick's Second Law-Non-steady-State Diffusion - Factors That Influence Diffusion - Diffusion in Semiconducting Materials

Module 3
Dislocations and Strengthening Mechanisms

Dislocations and Plastic Deformation - Basic Concepts -Characteristics of Dislocations - Slip Systems - Slip in Single Crystals - Plastic Deformation of Polycrystalline Materials -Deformation by Twinning. Recovery, Recrystallization and Grain Growth - Recovery -Recrystallization - Grain Growth. Fracture -Fundamentals of Fracture -Ductile Fracture - Brittle Fracture - Principles of Fracture Mechanics-Fracture Toughness Testing. Fatigue - Cyclic Stresses - The *S-N* Curve - Crack Initiation and Propagation - Factors that Affect Fatigue Life - Environmental Effect. Creep - Generalized Creep Behaviour - Stress and Temperature Effects.

Module 4
Phase Diagrams

Definitions and Basic Concepts - Solubility Limit - Phases - Microstructure - Phase Equilibria - One-Component (or Unary) Phase Diagrams. Binary Phase Diagrams - Binary Isomorphous Systems - Interpretation of Phase Diagrams - Development of Microstructure in Isomorphous Alloys - Mechanical Properties of Isomorphous Alloys - Binary Eutectic Systems - Development of

Microstructure in Eutectic Alloys - Materials of Importance - Lead-Free Solders - Equilibrium Diagrams Having Intermediate Phases.

Environmental, and Societal Issues in Materials Science and Engineering

Environmental and Societal Considerations - Recycling Issues in Materials Science and Engineering - Materials of Importance - Biodegradable and Bio-renewable Polymers.

Text for study:

'Materials Science and Engineering: An Introduction' by William D. Callister Jr. and David G. Rethwisch, John Wiley & Sons, Edition: 10th Edition (2020)

References:

- **"Introduction to Materials Science for Engineers" by James F. Shackelford,** Pearson, Edition: 9th Edition (2014)
- "The Science and Engineering of Materials" by Donald R. Askeland and Wendelin J. Wright, Cengage Learning, Eion: 7th Edition (2015)
- "Physical Metallurgy Principles" by Robert E. Reed-Hill and Reza Abbaschian, Cengage Learning, 4th Edition (2008)
- "Deformation and Fracture Mechanics of Engineering Materials" by Richard W. Hertzberg, Richard P. Vinci, and Jason L. Hertzberg, John Wiley & Sons, Edition: 5th Edition (2012)
- "Phase Transformations in Metals and Alloys" by David A. Porter and Kenneth E. Easterling, CRC Press, Edition: 3rd Edition (2009)
- "Materials Science and Engineering: A First Course" by V. Raghavan, Prentice Hall India, Edition: 6th Edition (2015)

MSPHN04E10: Biophysics and Bionanotechnology

Contact Hours: 72 (54 Lectures + 18 Tutorials)

Course Description: This course provides a comprehensive introduction to the principles and techniques of machine learning and data science. Students will learn about various machine learning algorithms, including supervised and unsupervised learning methods, and their applications in data analysis, pattern recognition, and decision-making. The course covers topics such as data preprocessing, feature engineering, model evaluation, and deployment. Emphasis is placed on hands-on experience with real-world datasets and the implementation of machine learning models using programming languages like Python.

Course Learning Outcomes:

CS01: Understand the physical principles governing biological systems at various scales, from molecules to cells and organisms.

CS02: Describe the structure and function of biomolecules, including proteins, nucleic acids, and membranes, and their role in biological processes.

CS03: Explain the principles and applications of various biophysical techniques, such as spectroscopy, microscopy, and diffraction methods, for studying biological systems.

CS04: Discuss the fundamental concepts and applications of bionanotechnology, including nanomaterials, nanodevices, and their applications in biotechnology and medicine.

CS05: Analyse and interpret experimental data related to biophysical and bionanotechnology studies.

CS06: Appreciate the interdisciplinary nature of biophysics and bionanotechnology and their potential impact on various fields.

Module 1: Introduction to Biophysics and Bionanotechnology (12 hours lecture, 4 hours tutorial)

- Overview of biophysics and bionanotechnology
- Physical principles in biological systems
- Biomolecular structure and function

- Introduction to nanomaterials and nanodevices for biological applications

Module 2: Biomolecular Structure and Interactions (14 hours lecture, 5 hours tutorial)

- Protein structure and folding
- Nucleic acid structure and interactions
- Lipids and membrane structure
- Molecular interactions and binding phenomena

Module 3: Biophysical Techniques (14 hours lecture, 5 hours tutorial)

- Spectroscopic techniques (UV-Vis, fluorescence, NMR, etc.)
- Microscopy techniques (optical, electron, atomic force microscopy)
- Diffraction methods (X-ray crystallography, small-angle scattering)
- Biophysical applications and data analysis

Module 4: Bionanotechnology (14 hours lecture, 4 hours tutorial)

- Nanomaterials for biological applications (nanoparticles, nanotubes, nanopores)
- Nanodevices for biosensing, bioimaging, and drug delivery
- Biomimetic and bio-inspired nanotechnology
- Ethical and safety considerations in bionanotechnology

Textbook:

3 "Physical Biology of the Cell" by R. Phillips, J. Kondev, J. Theriot, and H. Garcia, Garland Science, 2nd edition, 2012.

4 "Nanobiotechnology: Principles and Applications," Juhi Saxena, Abhijeet Singh, Anupam Jyoti (Eds.), 2023, Bentham Books imprint.

References:

16 "Biological Physics: Energy, Information, Life" by P. Nelson, W.H. Freeman and Company, 2nd edition, 2020.

17 "Introduction to Bionanotechnology" by S.S.R. Pappu and A.V. Ramana, CRC Press, 2021.

18 "Biophysics: An Introduction" by C.R. Cantor and P.R. Schimmel, W.H. Freeman and Company, 2018.

19 "Nanobiotechnology: Concepts, Applications and Perspectives" by C.M. Niemeyer and C.A. Mirkin, Wiley-VCH, 2004.

20 "Bionanotechnology: Lessons from Nature" by D. Shi, Wiley-VCH, 2013.

MSPHN04C19: Research Methodology & Experimental Techniques

(1 Credit, 2 Hrs/Week)

(Contact hours - 30 Hrs.) (26 Lectures+ 4 Tutorials)

Course Objectives:

To address research questions or test hypotheses, quantitative or qualitative data must be gathered, analysed, and interpreted using a systematic, scientific procedure known as research methodology. A research technique helps researchers stay on track by restricting the scope of the study, much like a plan for carrying out research. On completing the course, a student will be able to appreciate the scientific research methodology. To develop the capability of the students to find research problems, to conduct research and to report the findings in an ethical manner, provide an introduction to technical writing, complex graphics, and computer presentations with LaTeX are the main concerns of the course.

Part A

Module 1: Scientific Research and Methodology (12 Hours)

Definitions, Meaning and characteristics of research - Types of Research and importance of research activities - Planning and designing research activity - Definition, characteristics, rules and principles of scientific method - Hypothesis- Definition, types of hypothesis, sources of hypothesis and testing of hypothesis - Experimental design – principles, characteristics and types of experimental design (qualitative idea only)- Requirements of a good experiment - Interpretation and generalization of research findings.

[**Book 1**: Section 1.1-1.5, 3.4, 4.2-4.4, 4.6, 4.8]

Module 2: Scientific Writing (8 Hours+ 4Tutorials)

Importance and characteristics of scientific writing - Literature review, needs, planning and locating relevant literature, academic and general search engines, writing a literature review - Journals, scientific paper, review paper, short communication and rapid communication - Journal impact factor, citation index, h-index, g-index, hg- index, i10 index - Components of a scientific paper: title, abstract, key words, introduction, methodology, results and discussion, conclusion, references.

[**Book 1**: Section 6.2, 6.3-6.9, 7.1], [Tutorial: LaTeX at wikibooks.org]

Module 3: Research Ethics (6 Hours)

Importance of research ethics, values and principles of ethics - Intellectual property rights, examples for scientific misconduct, plagiarism, different forms of plagiarism and methods to avoid plagiarism, tools for plagiarism checking - Costs of scientific misconduct and dealing with scientific misconduct - Research ethics committees and functions.

[**Book 1**: 9.1.-9.5, 9.7-9.9]

Part B

Introduction of free open-source software Latex, basics, mathematical typesetting, graphics and tables, familiarization of document, research paper templates and beamer presentations.

[LaTeX at wikibooks.org, MOOC, UGC-Swayam, Coursera, edX, NPTEL]

Book for Study

1 K. Prathapan, "*Research Methodology for Scientific Research*" (Second Edition), iK International Publishers, New Delhi, (2023).

References

1. C. George Thomas, "*Research Methodology and Scientific Writing*" Springer (2021).

2. Suresh Chandra and Mohit Kumar Sharma, "*Research Methodology*", Narosa Publishing House PVT. Ltd, New Delhi, (2013).

3. C. R. Kothari, "*Research Methodology- Methods and Technique*", New Age International (2004)

4. Santhosh Kumar Yadav, "Research and Publication Ethics". Anne Books PVT. Ltd. New Delhi (2022)

5. Dilip Dutta "*Good Practices and Ethics in Research and Publication*", Anne Books PVT. Ltd, New Delhi (2021).

6. Upendra Prathap Singh "*Research and Publication Ethics*", S Chand Publishing (2023).

7. Pankaj Mittal and Sistla Rama Devi Pani "*Reimagining Indian Universities*" Association of Indian Universities (2020)

8. Yogesh Kumar Singh, "*Fundamentals of Research Methodology and Statistics*", New Age International (2006)

MODEL QUESTION PAPERS

First Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN01C01: Classical Mechanics

Time: 3 Hours Max. Marks: 60

SECTION-A

(Answer **ANY FIVE** questions. **Each** question carries **3** marks)

1 What are constraints? Distinguish between holonomic and non-holonomic constraints with examples.

2 What are cyclic coordinates? What is their physical significance?

3 What is meant by Poisson's bracket of dynamical variables? State any four properties of Poisson's bracket.

4 Define the Hamiltonian of a system. What is its physical significance?

5 Explain briefly the conditions for stable and unstable equilibrium for a system executing small oscillations.

6 What do you understand about the inertia tensor and principal moments of inertia?

(5 x 3 = 15)

SECTION-B

(Answer **ANY THREE** questions. **Each** question carries **6** marks)

7 (i) The Lagrangian of particle moving in one dimension is given by $L = \frac{\dot{x}^2}{2x} - V(x)$. Find the corresponding Hamiltonian.

(ii) A system is represented by the time dependent Lagrangian$L = e^{\gamma t}[\frac{1}{2}m\dot{x}^2 - V(x)]$, where γ is a constant. Deduce the equation of motion of the system.

8 Define phase space of a system. Draw the phase space trajectories for:

i A free particle of mass 'm' and kinetic energy E, moving in a 1-D box with perfectly rigid walls at x = 0 and x = L.

i A one dimensional harmonic oscillator.

9 Show that the transformation $P = q\cot p,\ Q = \log(\frac{\sin p}{q})$ is canonical and hence finds its generating function. To which type this generating function belongs to?

10 Using calculus of variation, show that the trajectory of a particle of mass *m* falling under gravity in the shortest time will be a cycloid.

11 (i) Discuss the origin of fictitious forces and hence obtain expressions for Centrifugal and Coriolis forces.

ii Prove that freely falling objects deflect from their vertical path. **(3 x 6 = 18)**

SECTION-C

(Answer **ANY THREE** questions. **Each** question carries **9** marks)

12 State Hamilton's principle and use it to derive the Lagrange's equations of motion.

13 What do you mean by central forces? Prove that the orbit of a planet moving under an inverse square law force is a conic and classify the orbits on the basis of total energy.

14 Define and illustrate Euler's angles involved in the transformation from one set of a three dimensional coordinate system to another having the same origin. Obtain the complete transformation matrix for such a transformation.

15 What are action-angle variables? Explain how they can be used to obtain the frequencies of periodic motion and hence determine the frequency of a linear harmonic oscillator.

16 Establish the Lagrangian and hence deduce Lagrange's equation of motion for small oscillations of a system in the neighborhood of stable equilibrium.

(3 x 9 = 27)

First Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN01C02-Mathematical Physics 1

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1 Explain the procedure for diagonalizing a matrix.
2 Write down the Maxwell equations in tensor form.
3 State the Weierstrass M test for the uniform convergence of a series of functions.
4 Show that $\Gamma(p+1) = p\Gamma(p)$.
5 What is a double factorial function? Explain.
6 Find the Fourier cosine and Fourier sine transforms of the function $f(x) = k, if 0 < x < a; \wedge f(x) = 0, if x > a$.

Section B

(Answer any 3, Each one carries 6 marks)

7 Prove that eigenvectors corresponding to different eigenvalues are orthonormal.
8 What is a metric tensor? Given a simple 2-dimensional space described by the polar coordinates (r, θ), write down the metric tensor g_{ij} in this coordinate system.
9 Find and graph solutions of the system of equations:

$$y_1' = -3y_1 + y_2$$

$$y_2' = y_1 - 3y_2$$

10 Discuss the linearity property of Fourier transform.
11 Obtain the generating function for Laguerre polynomials.

Section C

(Answer any 3, Each one carries 9 marks)

12 Find eigenvalues of the matrix A= and the eigenvector corresponding to its largest eigenvalue.
13 State and prove Leibniz's rule for the convergence of an alternating series.
14 Obtain the Fourier series of the function $f(x) = x^2 (-\pi < x < \pi)$
15 Obtain the series solution to the Bessel's equation $x^2 y'' + xy' + (x^2 - n^2)y = 0$.
16 Solve the one-dimensional heat equation using the method of separation of variables.

First Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN01C03 - Electrodynamics

Time: 3 Hours **Max. Marks: 60**

Section A

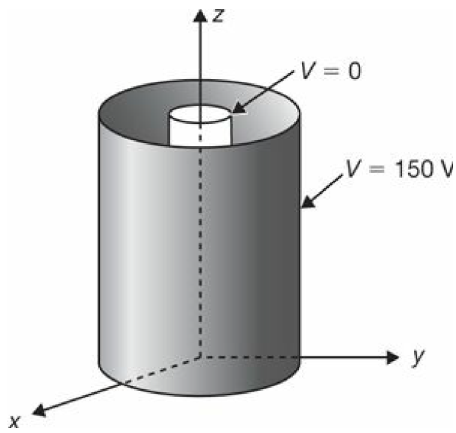
(Answer any 5, each question carries 3 marks)

1 Explain the concept of Method of images.
2 State Poynting's theorem and explain Poynting's vector.
3 Define Brewster's angle and critical angle
4 Explain the concept of retarded potential.
5 Differentiate between a transmission line and a waveguide.
6 Describe the Covariant formulation of Maxwell's equations

Section B

(Answer any 3, each question carries 6 marks)

7 How Poynting's theorem can be interpreted for the microscopic fields $(\vec{E}, \vec{B})$ as a statement of conservation of energy of the combined system of particles and fields.
8 Imagine a futuristic world where electromagnetism works differently from our current understanding. Design a novel electromagnetic field tensor that describes the interactions between electric and magnetic fields in this unique universe. Describe the components and properties of this tensor.
9 A charge of +3C is suspended in the air at a distance of 30 units from a celestial, grounded conducting sphere with a radius of 2 units. It is your duty to find the secrets of this peculiar system. Using your knowledge of image charge methods, calculate the position and magnitude of the mysterious image charge that appears due to the presence of the grounded conducting sphere.
10 Using your imagination as a wizard of physics, discover the potential function and the electric field intensity for the region between two concentric right circular cylinders as shown in figure, where $V = 0$ at $r = 1$ mm and $V = 150$ V at $r = 20$ mm.



11 You are a physicist exploring waveguide properties. The rectangular waveguide has dimensions of 2.5 cm and 5 cm and you need to determine its guide wavelength, phase velocity, and phase constant for the dominant mode at a wavelength of 4.5 cm. Design a series of calculations that can uncover the waveguide's characteristics.

Section C

(Answer any 3, each question carries 9 marks)

12 Derive Laplace’s equation in spherical polar coordinates. Give a general procedure for solving it.

13 Discuss with necessary theory the case of oblique incidence of electromagnetic waves at the interface of two non-conducting media and hence obtain Fresnel’s equations.

14 Give an account of Lienard and Wiechert potentials and find an expression for the field of a charge in uniform motion.

15 Consider a charged particle with mass 'm,' charge 'q,' and acceleration 'a.' Utilizing Maxwell's equations, Lorentz force law, and the concept of radiation reaction, trace the step-by-step derivation of the Abraham-Lorentz formula.

16 Obtain Lorentz transformation equations and prove that they are orthogonal.

First Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN01C04-Electronics

Time: 3 Hours **Max. Marks: 60**

Section A

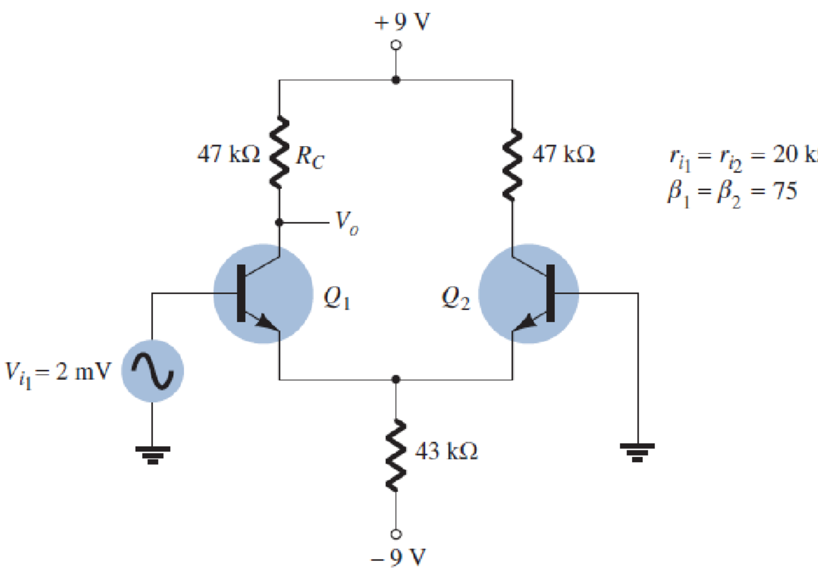
(Answer any 5, Each one carries 3 marks)

1 What are the characteristics of an Ideal OPAMP? Draw the block diagram of an OPAMP..
2 What do you mean by the transfer characteristics of an OPAMP, Draw the transfer characteristics of an OPAMP.
3 Define the Slew rate and briefly explain its significance?
4 What are Multiplexers and why do we need them?
5 Differentiate between synchronous and Asynchronous counters?
6 Differentiate between Microprocessors and Microcontrollers?

Section B

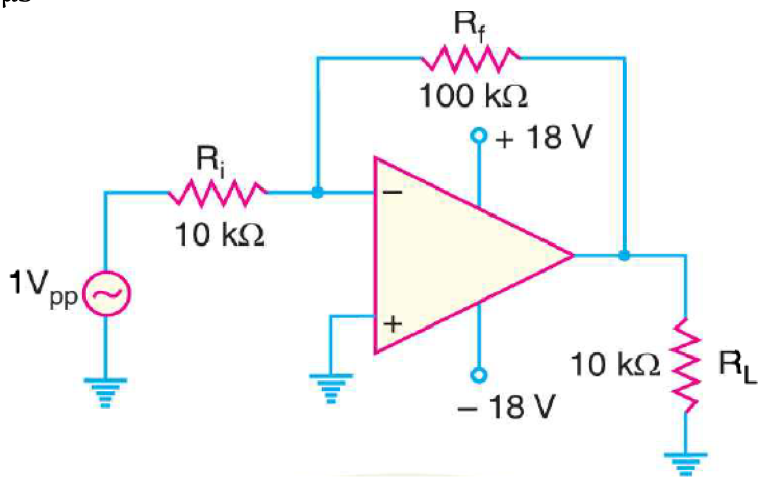
(Answer any 3, Each one carries 6 marks)

7 Calculate the single-ended output voltage V_{o1} for the given circuit?



8 Design a Second order high pass filter with a cut-off frequency of 1KHz (capacitors of 0.0047μF are given)?
9 Convert an S-R Flip Flop to a J-K Flip Flop?
10 Design a Synchronous 3-bit Up/Down counter?

11 For the circuit shown in the figure find (i) closed loop voltage gain (ii) input impedance of the circuit (iii) the maximum operating frequency. The slew rate is 0.5V/μS



Section C

(Answer any 3, Each one carries 9 marks)

12 Explain the DC & AC analysis of a Differential amplifier using transistors?

13 Draw the block diagram representation of different feedback configurations & Explain the Voltage series feedback amplifier?

14 Draw the circuit diagram and explain the working of (i) a Square wave generator and (ii) a Triangular wave generator?

15 What is the race-around condition in Flip Flops and how is it resolved by using the Master-Slave flip flop?

16 Explain the architecture of 8085 Microprocessors?

Second Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN02C08 - Quantum Mechanics 1

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1 What are stationary states? Define the expectation value of a stationary state.
2 What is meant by the zero point energy of a harmonic oscillator? How is the quantum oscillator different from its classical counterpart?
3 What are Unitary transformations? How do kets and bras transform under unitary transformation?
4 Give the fundamental postulates of quantum mechanics.
5 Define angular momentum operator in spherical polar coordinates.
6 Define the translation operator and explain its hermiticity.

Section B

(Answer any 3, Each one carries 6 marks)

7 A particle in the infinite square well has the initial wave function $\psi(x,0) = Ax(a - x)$, $(0 \leq x \leq a)$, for some constant A. Find $\psi(x,t)$
8 Show that the eigenvalues of a Hermitian operator are real and the eigenfunctions corresponding to different eigenvalues are orthogonal.
9 Obtain the Pauli's spin matrices and show that they are Hermitian and traceless
10 Obtain the angular momentum matrices for j=3/2
11 Imagine two non-interacting particles, each of mass m, in the infinite square well. If one is in the state ψ_n and other in state ψ_l $(l \neq n)$. Calculate $\langle (x_1 - x_2)^2 \rangle$ assuming they are distinguishable particles.

Section C

(Answer any 3, Each one carries 9 marks)

12 Discuss the finite square well potential problem in 1D and obtain the transmission coefficient
13 Derive the general uncertainty relation and explain the position momentum uncertainty principle
14 What are CG Coefficients? Obtain the selection rules and recursion relations.
15 Discuss the problem of conservation of angular momentum as a consequence of the rotational invariance of the system.
16 Discuss the harmonic oscillator problem in algebraic methods. Obtain the energy eigenvalues.

Second Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN02C09- Statistical Mechanics

Time: 3 Hours **Total Marks: 60**

Section A

(Answer ANY FIVE questions, each carry 3 Marks)

1 Discuss about Microstates and Macrostates with examples. Write Boltzman's relation connecting the number of microstates and entropy.

2 Discuss briefly about the term critical exponents in the case of phase transitions.

3 Distinguish between ideal Bose and ideal Fermi systems.

4 Discuss about the Boltzman distribution and its importance.

5 Explain the importance of Grand potential, how it is connected to the thermodynamic properties of a system.

6 Explain intensive and extensive properties of a system , give examples.

(5X3 = 15)

Section B

(Answer ANY THREE questions, each carry 6 Marks)

7 Discuss about the concept of phase space, deduce the phase space of a one dimensional classical harmonic oscillator.

8 (a)Deduce the form of the canonical partition function.

(b) The lowest energy level of 02 is threefold degenerate. The next level is doubly degenerate and lies 0.97eV above the lowest level. Take the lowest level to have an energy of 0. Calculate the partition function at 1000K and at 3000K.

9 The entropy of a two-dimensional gas of particles in an area A is given by the expression

S=Nk[log(A/N)+log(mU/2πNђ^2)+2]

where Nis the number of particles and U is the energy of the gas. Calculate the temperature of the gas and the chemical potential.

10 Consider two identical particles which are to be placed in four single-particle states. Two of these states have energy 0, one has energy ϵ, the last has energy 2ϵ. Calculate the partition function given that the particles are (a)fermions and (b) bosons.

11 (a)Show that the average energy per particle in a non-relativistic Fermi gas at the absolute zero of temperature in three dimensions is

U=3E_F/5

(b)In sodium there are about 2.6x1028 conduction electrons per cubic metre which behave as a free electron gas. From these facts estimate the Fermi energy of the gas and an approximate value of the molar electronic heat capacity at 300 K.

(3X6 = 18)

Section C

(Answer ANY THREE questions, each carry 9 Marks)

12 Explain Gibbs Paradox taking the example of mixing of classical ideal gases. Discuss how Gibbs paradox is resolved.

13 Discuss about the energy fluctuation and density fluctuation for a thermodynamic system in a grand canonical ensemble.

14 What is the nature and importance of Bose Einstein distribution function? Discuss Bose Einstein Condensation and find the thermodynamic properties of the condensed phase.

15 Discuss the magnetic behavior of ideal Fermi gas and explain Landau Diamagnetism.

16 What is meant by continuous phase transition? Explain the Ising model which exhibits the magnetic phase transition.

(3X9 = 27)

Second Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN02C10-Mathematical Physics II

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1 What is an analytic function? Check whether the function $f(z) = z^2$ is analytic or not.
2 Develop the function $\frac{1}{(1-z)}$ in negative powers of z
3 Find the Laplace transform of the function $f(t) = 1$ for $t \geq 0$
4 Discuss homomorphism and isomorphism between groups.
5 Briefly explain the Gauss–Seidel Iteration method.
6 What is meant by goodness of fit? Explain the importance of the χ^2-test.

Section B

(Answer any 3, Each one carries 6 marks)

7 Obtain the expression for the derivative of a complex function $f(z)$ from the Cauchy's integral formula.
8 Evaluate inverse Laplace transform of the function $\frac{s^2}{(s^2+a^2)(s^2+b^2)}, a^2 \neq b^2$.
9 Explain the $SU(n)$ groups.
10 Find the positive solution of $2\text{sinsin}x = x$ using Newton's method.
11 A box contains 10 screws, three of which are defective. Two screws are drawn at random. Find the probability that neither of the two screws is defective.

Section C

(Answer any 3, Each one carries 9 marks)

12 State and prove Cauchy's integral formula.
13 State and prove the convolution theorem for Laplace transform.
14 What are orthogonal groups? Show that an $n \times n$orthogonal matrix has $\frac{n(n-1)}{2}$ independent elements.
15 Explain the Runge–Kutta methods for systems. Use the method to solve the Airy's equation.
16 Explain the point estimation of parameters. Find maximum likelihood estimates for $\theta_1 = \mu$ and $\theta_2 = \sigma$ in the case of the normal distribution.

First Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN02C11: Spectroscopy

Time: 3 Hours Max. Marks: 60

Section A
(Answer any 5, each one carries 3 mark)

1 State Paschen-Bach effect and Stark effect
2 Distinguish normal and anomalous Zeeman Effect.
3 What are hot bands? Give expression for the same.
4 Discuss the normal vibrations of CO_2 molecules.
5 State Franck-condon principle.
6 What is Larmor precession? Give expression for Larmor frequency.

Section B
(Answer any 3, each one carries 6 mark)

7 Discuss with example L-S and j-j coupling for atoms with two outer valence electrons. Calculate the possible j values for s, p and d orbitals.
8 Outline the quantum theory of anomalous Zeeman Effect and arrive at the Zeeman shift.
9 The average spacing between successive rotational lines of a CO molecule is 3.8626 cm^{-1}. Determine the transition which gives the most intense spectral line at temperature 300 K.
10 Illustrate vibrational Raman spectra for harmonic oscillators and arrive at the wave numbers of stokes and anti-stokes lines.
11 Calculate the recoil velocity of a free Mossbauer nucleus of mass 1.67×10^{-25} kg when emitting a γ-ray of wavelength 0.1 nm. What is the Doppler shift of the γ-ray frequency?

Section C
(Answer any 3, each one carries 9 mark)

12 Discuss the rotational energy levels of a diatomic molecule, considering it as a non-rigid rotator. Discuss how centrifugal distortion influences the spectrum.
13 Give an account of rotational fine structure of electronic-vibration spectra. Discuss band origin and band head.
14 Discuss Frank-Condon principle and illustrate how it accounts for intensity variation of spectral lines. How can we account for dissociation and predissociation in molecules?
15 Outline the theory of NMR and ESR. Illustrate with an example.
16 Explain the basic principle of Mossbauer spectroscopy. Briefly discuss various applications of the technique.

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03C13: Quantum Mechanics II

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1 What is dipole approximation?

2 Define scattering cross section and differential scattering cross section

3 Briefly explain variational principle

4 Briefly explain hole theory and negative energy states

5 Explain Optical theorem.

6 Write a short note on Dirac's matrices.

Section B

(Answer any 3, Each one carries 6 marks)

7 Discuss the quantization of Schrodinger field, explain how it is used for a system of Bosons.

8 Find the ground state energy of a harmonic oscillator using a trial wave function by variational method.

9 A particle which is initially (t=0) in the ground state of an infinite, one dimensional potential box with walls at x=0 and x=a, is subjected for $0 \leq t \leq \infty$ to a perturbation $V(t) = x^2 e^{-t/\tau}$. Calculate to first order the probability of finding the particle in its first excited state for $t \geq 0$

10 Obtain Weyl equation for Neutrinos, also explain parity violation in a process involving neutrinos.

11 Obtain Klein Gordon equation and explain how it leads to positive and negative probability density values.

Section C

(Answer any 3, Each one carries 9 marks)

12 Discuss the first order time independent perturbation theory for nondegenerate stationary state. Obtain the first order eigen value and eigen function.

13 Using time dependent perturbation theory, derive an expression for transition probability under harmonic perturbation.

14 Explain the method of partial wave analysis. Obtain the formula for expanding a plane wave in terms of partial wave.

15 Discuss the first order Born approximation in scattering theory. Obtain the condition for the validity of Born approximation.

16 Derive the spin orbit interaction energy using the Dirac equation.

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03C14: Condensed Matter Physics

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1. Write a short note about phonons.
2. What is Laue equation? What is it's relevance?
3. What is Clausius Mosotti relation?
4. Write a short note about superconductivity.
5. Briefly explain the Hall effect.
6. What is Bloch theorem of electron in a periodic potential?

Section B

(Answer any 3, Each one carries 6 marks)

7. An X-ray diffraction (XRD) pattern was obtained for a nickel sample to investigate its crystal structure at room temperature. Upon analysis of the XRD pattern, it was noted that the (110) plane is absent. Based on this observation, what is the the crystal structure of nickel at room temperature? Write down the relevant equations and theory to support your conclusion.
8. Calculate the Hall coefficient of sodium based on free electron model. Sodium has bcc structure with a lattice parameter of 4.28Å.
9. The critical magnetic field of a superconductor at temperatures 4K and 8K are 11mA/m and 5.5mA/m respectively. What is the transition temperature?
10. The magnetic field strength in silicon is 1000A/m. If the magnetic susceptibility is -0.3 x 10^{-5}. Calculate the magnetization and the flux density of silicon.
11. In a crystalline solid, the energy band structure (E-K relation) for an electron of mass m is given by, $E = \frac{\hbar^2 K(2K-3)}{2m}$. What is the effective mass of electron within the crystal?

Section C

(Answer any 3, Each one carries 9 marks)

12. Show that the dispersion relation of the vibration of crystals with monoatomic basis is $\omega = (\frac{4C}{M})^{\frac{1}{2}} \left|Sin\ \frac{1}{2}\mathrm{Ka}\right|$. Draw the dispersion curve and mark the values at the boundaries.
13. Discuss the Kronig-Penney model for the motion of electrons in a periodic potential. Draw E Vs K diagram.
14.
    (a) Derive the diffraction condition, $\Delta k = G.$ in reciprocal space.
    (b) What is a brilliour Zone? Draw first and second Brillioune zone of a two-dimensional lattice.

15. (a) Describe Langevin's theory for a paramagnetic gas and obtain an expression for the paramagnetic susceptibility of a free electron gas.

(b) How does paramagnetic susceptibility vary with temperature?

16. (a) What is the Meisner effect? Briefly discuss about the classification of super conductor based on Meisner effect.

(b) Give the basis of London theory. Derive the London equations.

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03C15: Nuclear & Particle Physics

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any **5** questions, each carries **3 marks**)

1. What are strange particles? Why it is called strange.
2. Give an account of the failure of liquid drop model.
3. What is internal conversion ? Under what condition this process complete with gamma transition?
4. Explain how the nuclear stability depends on the binding energy.
5. Why diproton and dineutron do not have any ground state?
6. Briefly mention the applications of nuclear fission and fusion.
7. Write a note on mass distribution of fission fragments.
8. Discuss the magnetic and electric moments of deutron.

Section B

(Answer any **3** questions, each carries **6 marks**)

1. Use shell model to predict the spin and parities of the ground states of $^{17}\mathbf{O}$, $^{25}\mathbf{Mg}$ and $^{27}\mathbf{Pb}$.
2. Calculate the magnetic moments and quadrupole moments of $^{39}\mathbf{K}$, $^{25}\mathbf{Mg}$ and $^{27}\mathbf{Pb}$.
3. Write a note on Yukawa's proposal and obtain mass of pion using Heisenberg uncertainty relation.
4. Find out which one doesn't conserve strangeness quantum number.
   a. $\pi^0 + p \longrightarrow k^+ + \Lambda^0$
   b. $\pi^- + p \longrightarrow k^0 + \Lambda^0$
   c. $\Delta^0 \longrightarrow \pi^0 + n$
   d. $K^0 \longrightarrow \pi^+ + \pi^-$
5. Determine the mass difference between two mirror nuclei which have N and Z differing by one unit and the same value of odd A.

Section C

(Answer any **3** questions, each carries **9 marks**)

1. a. What is meant by TCP theorem ? (3 Marks).

   b. Show that parity and charge conjugation operator is not conserved in weak interaction with an example. (6 Marks)

2. a. Discuss the main features of Shell model (4 Marks).

   b. Explain how magnetic and electric moments calculated using spin-orbit potential (5 Marks).

3. a. Discuss Fermi theory of beta decay (5 Marks).

   b. What are allowed and forbidden transitions in beta decay ? (4 Marks)

4. a. Discuss the The eight fold way of hadrons (5 Marks).

   b. What are the experimental evidence for quark model (4 Marks).

5. a. Give a brief account of nuclear fission reactor (5 Marks).

   b. Explain in detail about the neutron emission in fission (4 Marks).

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03O01: Machine Learning and Data Science

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Explain the difference between supervised and unsupervised learning in machine learning.
2 What is the purpose of feature scaling in data preprocessing?
3 Define the bias-variance trade-off in the context of machine learning models.
4 Briefly explain the k-means clustering algorithm.
5 What is the purpose of cross-validation in model evaluation?
6 Name two popular Python libraries for machine learning and their primary use cases.

Section B (Answer any 3 questions, 6 marks each)

7 Describe the principles of decision tree algorithms and their advantages and limitations.
8 Explain the concept of regularisation in linear regression and its importance in preventing overfitting.
9 Discuss the dimensionality reduction technique of Principal Component Analysis (PCA) and its applications.
10 Implement the k-Nearest Neighbours (k-NN) algorithm for a classification problem using Python and the scikit-learn library.
11 Explain the concept of ensemble learning and discuss two popular ensemble methods (e.g., random forests, boosting).

Section C (Answer any 3 questions, 9 marks each)

12 Derive the cost function and learning algorithm for logistic regression. Explain how it can be used for binary classification problems.
13 Discuss the architecture and training process of artificial neural networks. Explain the backpropagation algorithm for training neural networks.
14 Explain the principles of Support Vector Machines (SVMs) and their use for classification and regression problems. Discuss the concept of kernel functions in SVMs.
15 Describe the hierarchical clustering algorithm and its applications in data analysis. Explain the different linkage methods used in hierarchical clustering.
16 Discuss the challenges and best practices in dealing with imbalanced datasets in machine learning. Explain techniques like oversampling, under sampling, and class weighting to address class imbalance.

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03O03: Environmental Physics and Earth Sciences

Time: 3 Hours **Max. Marks: 60**

SECTION-A
(Answer ANY FIVE questions. Each question carries 3 marks)

1. Describe the vertical structure of the Earth's atmosphere.
2. Explain the concept of radiative transfer in the atmosphere.
3. What is the greenhouse effect and how does it contribute to global warming?
4. Define Hadley cells and describe their role in atmospheric circulation.
5. Summarize the key mechanisms of the Indian monsoon.
6. What are seismic waves and how are they utilized in geophysical exploration.
7. Describe the principles of environmental monitoring.
8. Explain the role of remote sensing in environmental monitoring.

SECTION-B
(Answer ANY THREE questions. Each question carries 6 marks)

9. Design an experiment to measure the impact of varying levels of greenhouse gases on atmospheric temperature.
10. Propose a method for using seismic reflection techniques to identify potential earthquake-prone zones.
11. Create a plan to monitor air quality in urban areas using sensor networks, based on principles.
12. Design a study to assess the effectiveness of renewable energy sources in reducing carbon emissions.
13. Develop a framework for using GIS to analyze the spatial distribution of soil pollution.

SECTION-C
(Answer ANY THREE questions. Each question carries 9 marks)

14. Analyze the impact of climate change on the variability of the Indian monsoon, using insights.
15. Evaluate the use of remote sensing techniques for early warning of volcanic eruptions.
16. Apply statistical analysis methods to evaluate air quality trends in a metropolitan area, based on principles.
17. Discuss the role of sustainable development goals (SDGs) in addressing major environmental challenges.
18. Analyze the potential benefits and challenges of implementing large-scale solar energy projects to combat climate change.

19. Evaluate the use of geophysical exploration techniques in locating groundwater resources.

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03O04: Physics in Disaster Management: Understanding and Mitigating Natural Hazards

Time: 3 Hours **Max. Marks: 60**

SECTION-A
(Answer ANY FIVE questions. Each question carries 3 marks)

1. What are the primary types of seismic waves generated during an earthquake? Briefly describe each type.
2. Explain the basic mechanism behind the formation of tsunamis.
3. What are the key factors that influence the intensity and impact of tropical cyclones?
4. What are the primary principles of mechanics applied in search and rescue operations?
5. Define probabilistic seismic hazard analysis (PSHA) and its importance in risk assessment.
6. How do tsunami early warning systems work to detect and alert coastal communities?
7. Describe the role of materials science in designing cyclone-resistant structures.
8. What are the key environmental challenges addressed during the recovery phase of a disaster?

Section B
(Answer ANY THREE questions. Each question carries 6 marks)

9. Design a basic search and rescue operation plan for a post-earthquake urban area, incorporating principles of mechanics and thermodynamics.
10. Develop a numerical simulation model to predict the inundation levels of a coastal area following a tsunami event.
11. Propose a comprehensive floodplain management plan for a city prone to frequent flooding, using physics-based approaches.
12. Create a risk assessment model integrating physics principles and engineering techniques to evaluate cyclone impacts on a coastal infrastructure.
13. Design an early warning system for tsunamis, outlining the key components and their functions based on physics principles.

Section C
(Answer ANY THREE questions. Each question carries 9 marks)

14. Analyse the propagation dynamics of seismic waves through different geological formations and evaluate their implications for earthquake damage prediction.

15. Apply the principles of hydrodynamics to evaluate the effectiveness of existing flood control measures in a riverine area and suggest improvements.
16. Assess the socio-economic impacts of a recent natural disaster and propose physics-informed strategies for enhancing community resilience and recovery.
17. Evaluate the structural integrity of a building designed with earthquake-resistant techniques during a major seismic event. Discuss the physics principles applied.
18. Analyse the environmental contamination issues following a natural disaster and propose physics-based solutions for ecological restoration.
19. Evaluate the physical mechanisms of cyclone formation and their impact on global weather patterns. Discuss how understanding these mechanisms can aid in disaster preparedness and mitigation.

Third Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN03O05: Wonders of Quantum World

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5, Each one carries 3 marks)

1. Briefly explain the Bohr's quantum theory
2. Write a short note on the Copenhagen interpretation of quantum theory
3. What are quantum wires? Give examples
4. Define a qubit
5. Briefly discuss the concept of quantum entanglement
6. What are quantum dot lasers?

Section B

(Answer any 3, Each one carries 6 marks)

7. Analyse the development of Planck's quantum hypothesis and its revolutionary impact on the advancement of quantum physics.
8. Discuss the dual wave particle hypothesis in view of the Davisson Germer experiment and Thomson's experiment.
9. Explain the Schrodinger's cat paradox.
10. Discuss the size effects in quantum nanostructures
11. How are qubits realised?

Section C

(Answer any 3, Each one carries 9 marks)

12. Discuss (i) the contribution of Albert Einstein in the development of quantum physics (ii) Einstein's thought experiments and his debates with Bohr
13. Discuss (i) EPR Paradox (ii) Bell's inequality
14. Explain lithography. How are quantum nanostructures made using lithographic techniques?
15. Discuss (i) the basic principles of quantum computing (ii) Quantum entanglement
16. Explain the working of (i) IR detectors (ii) quantum dot lasers

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E01: Computational Physics

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 What is the difference between explicit and implicit numerical methods for solving ordinary differential equations? Give an example of each.
2 Explain the concept of numerical precision and its importance in computational physics.
3 Write a Python function to implement the Euler method for solving a first-order ordinary differential equation.
4 Define the Metropolis algorithm and its applications in Monte Carlo simulations.
5 What is the significance of the Courant-Friedrichs-Lewy (CFL) condition in finite difference methods for solving partial differential equations?
6 Briefly explain the concept of parallel programming and its importance in computational physics.

Section B (Answer any 3 questions, 6 marks each)

7 Derive the finite difference approximation for the second-order derivative using a central difference scheme. Discuss the order of accuracy and the truncation error associated with this approximation.
8 Implement the fourth-order Runge-Kutta method in a programming language of your choice for solving the following initial value problem: $\frac{dy}{dt} = t^2 + y^2, y(0) = 1$. Solve for t = 0 to t = 2 with a step size of 0.1.
9 Explain the concept of periodic boundary conditions in molecular dynamics simulations. Discuss its importance and applications.
10 Describe the finite element method for solving the one-dimensional Poisson equation: $\frac{d^2u}{dx^2} = f(x)$, 0<x<1 with appropriate boundary conditions.
11 Write a pseudocode to implement the Fast Fourier Transform (FFT) algorithm for computing the discrete Fourier transform of a given sequence.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the finite difference approximation for the two-dimensional diffusion equation: $\partial u/\partial t = D(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2})$ using an explicit scheme. Discuss the stability criteria and the numerical implementation of this scheme.
13 Explain the principles of the Monte Carlo integration method. Implement a program to estimate the value of π using the Monte Carlo integration technique.

14 Discuss the advantages and limitations of spectral methods compared to finite difference and finite element methods for solving partial differential equations. Provide examples of applications where spectral methods are particularly useful.

15 Describe the computational aspects of solving the time-dependent Schrödinger equation using the split-operator method. Discuss the numerical implementation and the potential applications of this method in quantum mechanics.

16 Explain the concept of high-performance computing (HPC) and its importance in computational physics. Discuss the challenges and considerations involved in parallelizing computational physics algorithms for HPC systems.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E02: Microprocessors and Digital Signal Processing

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 What are the different addressing modes in 8085 instructions set?
2 Differentiate between instruction cycles and machine cycles in the context of microprocessor timing.
3 Explain what is meant by memory mapped I/O.
4 What are the key components involved in 7-segment LED display interfacing?
5 Define the Z-transform and its significance in digital signal processing.
6 Describe the process of linear convolution using the Discrete Fourier Transform (DFT).

Section B (Answer any 3 questions, 6 marks each)

7 Design an assembly language program to add two 2-byte numbers stored in memory locations.
8 Briefly explain the various data transfer schemes from CPU/memory to I/O devices and vice-versa.
9 Draw the schematic diagram of intel 8253. What are its various operating modes?
10 Briefly describe 8051 microcontrollers.
11 Determine whether the following signals are periodic. If they are periodic, find the fundamental period
   a $x_1[n] = \cos(n)$
   b $x_2[n] = \cos(\frac{1}{5}\pi n)\sin(\frac{1}{3}\pi n)$
   c $x_3[n] = \sum_{k=-\infty}^{\infty} \delta[n-3k]$

Section C (Answer any 3 questions, 9 marks each)

12 Discuss the instruction set of the Intel 8085 microprocessor. Explain the different types of instructions available and their roles in programming the microprocessor.
13 Explain the need for interrupts in microprocessor systems. Discuss the different types of interrupts in the Intel 8085.
14 Give the architecture and operating modes of programmable peripheral interface Intel 8255.
15 A mechanic takes a sound sample of an engine and then relies on a machine to analyse that sample, looking for potential engine problems. He started reading in the sound file and extracted the data from it. To analyse the various frequency components and its impact, he performed radix-2 DIT-FFT with the data. Suppose a scaled sample data

sequence he analysed is given as $x[n] = \{1,1,1,1,0,0,0,0\}$, follow the corresponding signal flow graphs, keeping track of all the intermediate quantities by putting them on the diagrams to compute FFT. Compare the computational efficiency of the method he used in terms of the number of multiplications required, as compared with DFT.

16 Consider the interconnection of LTI systems as shown in the Fig. Q8

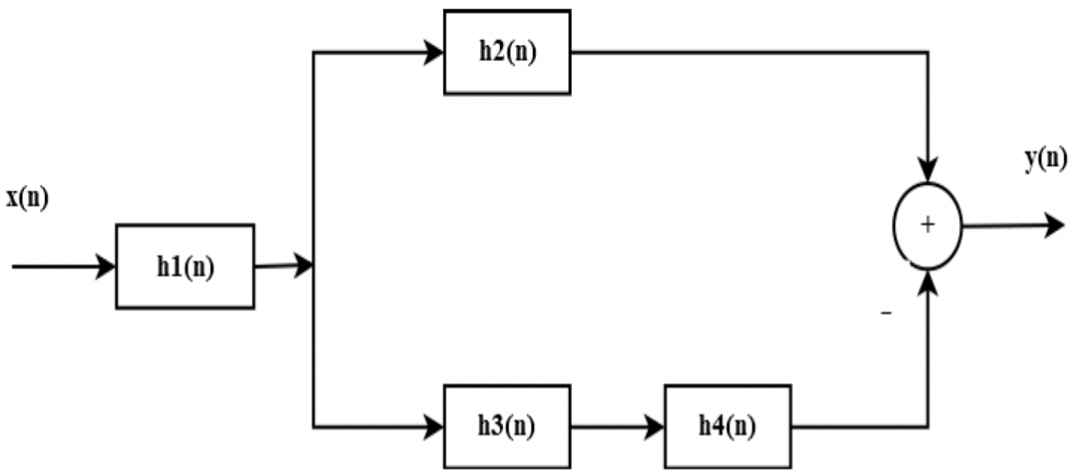


Fig. Q8

Determine the overall response $h(n)$ when

$$h1(n) = \left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{2}\right\}$$
$$h2(n) = h3(n) = (n+1)u(n)$$
$$h4(n) = \delta(n-2)$$

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E03: Quantum Optics and Computing

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the coherent state of the electromagnetic field and its properties.
2 What is the significance of Bell's inequalities in quantum mechanics?
3 Explain the concept of a quantum gate and its role in quantum computing.
4 Differentiate between spontaneous and stimulated emission in light-matter interactions.
5 What is the quantum advantage, and how does it relate to quantum computational complexity?
6 Briefly explain the principle of trapped ion quantum computing.

Section B (Answer any 3 questions, 6 marks each)

7 Derive the Jaynes-Cummings Hamiltonian for the interaction between a two-level atom and a quantized electromagnetic field.
8 Describe the Shor's algorithm for factoring large integers on a quantum computer. Discuss its significance and potential applications.
9 Explain the concept of quantum error correction and its importance in the implementation of fault-tolerant quantum computing.
10 Discuss the advantages and challenges of using photonic systems for quantum computing.
11 Write the quantum circuit for the Grover's algorithm to search for a marked element in an unstructured database of size N.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the Wigner function for the coherent state of the electromagnetic field. Discuss its properties and applications in quantum optics.
13 Explain the principles of quantum teleportation and its implementation using entangled states. Discuss the role of Bell's inequalities in the verification of quantum teleportation.
14 Discuss the concept of quantum computational complexity and the various complexity classes (P, NP, BQP, etc.). Explain how quantum computers can potentially solve certain problems more efficiently than classical computers.
15 Describe the superconducting circuit approach to quantum computing. Discuss the challenges involved in scaling up superconducting quantum computers and the techniques used to overcome them.
16 Derive the time-evolution operator for a two-level atom interacting with a classical electromagnetic field. Discuss the phenomena of Rabi oscillations and the rotating-wave approximation.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E04: Computational Materials Sciences

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the Born-Oppenheimer approximation and its significance in computational materials science.
2 What is the difference between first principles and empirical interatomic potentials in molecular dynamics simulations?
3 Explain the concept of pseudopotentials and their importance in electronic structure calculations.
4 Briefly describe the Monte Carlo method and its applications in materials science.
5 What is the finite element method, and why is it useful in studying the mechanical behaviour of materials?
6 Differentiate between concurrent and hierarchical multiscale modelling approaches.

Section B (Answer any 3 questions, 6 marks each)

7 Derive the Kohn-Sham equations in density functional theory (DFT) and discuss their significance in electronic structure calculations.
8 Explain the Metropolis algorithm and its implementation in Monte Carlo simulations for studying phase transitions in materials.
9 Discuss the advantages and limitations of classical molecular dynamics simulations in studying the structural and dynamical properties of materials.
10 Describe the finite element formulation for solving the elasticity problem in continuum mechanics and its applications in materials science.
11 Explain the concept of coarse graining in molecular simulations and its importance in bridging length and time scales.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the Hellmann-Feynman theorem and explain its significance in computing forces and stresses in first-principles calculations.
13 Discuss the reactive force field (ReaxFF) approach and its applications in studying chemical reactions and materials under extreme conditions.
14 Explain the principles of the finite element method for solving partial differential equations in continuum mechanics. Discuss its numerical implementation and the challenges involved.
15 Describe the concurrent multiscale modelling approach, including the handshaking region and its implementation for studying crack propagation in materials.

16 Explain the principles of accelerated sampling techniques, such as umbrella sampling and meta dynamics, used in molecular dynamics simulations to overcome the timescale limitations.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E05: Quantum Field Theory

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the canonical commutation relation for scalar field and its conjugate momentum.
2 Explain the concept of Gauge invariance in the case of Quantum Electrodynamics.
3 State Noether's theorem and describe its importance in Quantum Field theory.
4 Differentiate between canonical and path integral formulation of quantisation.
5 Explain the significance of Ward identities in gauge theories.
6 Draw Feynman diagram for electron-positron annihilation into a muon-antimuon pair.

Section B (Answer any 3 questions, 6 marks each)

7 State the Noether's theorem and show that a conserved current implies a conserved charge in the Lagrangian formulation of the classical field theory.
8 Obtain the inhomogeneous Maxwell's equation of motion from the Lagrangian density,

$$L = \frac{-1}{4} F^{\mu\nu} F_{\mu\nu} - j^{\mu} A_{\nu}.$$

9 Using Wick theorem, evaluate $0 \vee T(\phi^4(x)\phi^4(y)) \vee 0 >$.
10 Write down the definition of field operator $\hat{\phi}(\vec{x}, t)$ and conjugate momentum operator $\hat{\Pi}(\vec{x}, t)$ for the scalar fields. Then verify that they satisfy the equal time commutation relation:

$$[\hat{\phi}(\vec{x}, t), \hat{\Pi}(\vec{x}, t)] = i\delta^{(3)}(\vec{x} - \vec{y})$$

11 Explain the spontaneous symmetry mechanism and discuss the role of the scalar boson of zero electric charge in generating masses of the gauge boson and other particles.

Section C (Answer any 3 questions, 9 marks each)

12 The complex scalar field theory, $L = \partial_\mu \phi^\dagger \partial^\mu \phi - m^2 \phi^\dagger \phi$ is invariant under U (1) gauge transformation, i.e. $\phi \to \phi e^{i\alpha}$ and $\phi^\dagger \to e^{-i\alpha}\phi^\dagger$.
   12.a Show that the conserved current is, $j^\mu = i[(\partial_\mu \phi^\dagger)\phi - \phi^\dagger(\partial_\mu \phi)]$.
   12.b Write down the conserved charge Q.
13 Find the expression of Noether's conserved charge for a complex scalar field.
14 Briefly discuss the local gauge invariance of the massive Dirac field.
15 What is meant by the second quantisation? Prove that the equal time commutation relation, $[\phi(x, t), \phi(x', t)] = 0$.
16 Derive the expression of energy-momentum tensor $T^{\mu\nu}$ for the scalar field.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E06: Physics of Nano Systems

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the term "quantum confinement" and explain its significance in nanoscale systems.
2 What are the advantages of bottom-up approaches in nanotechnology?
3 Briefly describe Magnetron Sputtering method.
4 Explain how crystallite size is determined from XRD analysis.
5 Differentiate between 0-D, 1-D and 2-D nanostructures.
6 Mention some advantages of the sol-gel method.

Section B (Answer any 3 questions, 6 marks each)

7 Describe the particle-in-a-box model and its application in understanding the electronic properties of quantum dots.
8 Explain the optical properties of nanomaterials.
9 Discuss the principles and applications of scanning probe microscopy techniques used in characterising nanomaterials and nanostructures.
10 Write a short note on Nanomagnetism.
11 Explain the Coulomb Blockade effect.

Section C (Answer any 3 questions, 9 marks each)

17 Derive the expression for the energy levels and wave functions of a particle confined in a one-dimensional finite potential well.
18 Explain Quantization of conductance at low dimensions.
19 Briefly explain the working of TEM with the help of necessary theory.
20 Discuss any 2 chemical methods for the synthesis of thin films.
21 Discuss in detail about the Electrical, mechanical, magnetic and optical properties of nanomaterials.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E07: Nano Optics

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the near-field and far-field regions in the context of light-matter interactions at the nanoscale.
2 What is the significance of surface plasmon resonance in nano-optics?
3 Explain the concept of negative refractive index in metamaterials.
4 Briefly describe the principle of near-field scanning optical microscopy (NSOM).
5 What is the role of evanescent waves in nano-optics?
6 Differentiate between localised surface plasmons and surface plasmon polaritons.

Section B (Answer any 3 questions, 6 marks each)

7 Derive the dispersion relation for surface plasmon polaritons at a metal-dielectric interface.
8 Explain the concept of superlensing and its potential applications in nano-optics.
9 Discuss the finite-difference time-domain (FDTD) method for numerical simulations in nano-optics and its implementation.
10 Describe the principles and applications of plasmonic nanostructures in sensing and imaging.
11 Explain the concept of transformation optics and its role in the design of metamaterials.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the expressions for the electric field distribution and the associated enhancement factors in a metallic nanosphere under plane wave illumination.
13 Discuss the principles and applications of electron energy loss spectroscopy (EELS) and cathodoluminescence techniques in the characterization of nanophotonic devices.
14 Explain the design and working principles of a plasmonic waveguide and its potential applications in optical information processing.
15 Derive the effective medium theory for the effective permittivity and permeability of a metamaterial composed of split-ring resonators and thin wire arrays.
16 Describe the principles and implementation of a cloaking device based on transformation optics and metamaterials. Discuss the limitations and challenges involved in practical realisation.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E08: Thin Films, Crystal Growth and Characterization

Time: 3 Hours Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the term "epitaxial growth" and explain its significance in thin film and crystal growth.
2 What is the importance of vacuum technology in thin film deposition processes?
3 Briefly describe the working principle of a scanning electron microscope (SEM).
4 Explain the concept of critical nucleus size in the nucleation process during crystal growth.
5 Differentiate between homogeneous and heterogeneous nucleation.
6 What is the purpose of X-ray photoelectron spectroscopy (XPS) in the characterization of thin films?

Section B (Answer any 3 questions, 6 marks each)

7 Describe the three main growth modes of thin films (Frank-van der Merwe, Volmer-Weber, and Stranski-Krastanov) and their characteristics.
8 Explain the Czochralski method for crystal growth and its advantages and limitations.
9 Discuss the principles and applications of X-ray diffraction (XRD) in the characterization of thin films and crystals.
10 Derive the expression for the critical nucleus size in homogeneous nucleation, assuming a spherical shape.
11 Explain the concept of defects in crystals and their impact on material properties and device performance.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the Bragg's law for X-ray diffraction and explain how it can be used to determine the crystal structure and lattice parameters of thin films and crystals.
13 Discuss the principles and implementation of molecular beam epitaxy (MBE) for the growth of thin films and crystals. Explain the advantages and challenges of MBE compared to other deposition techniques.
14 Describe the principles and applications of transmission electron microscopy (TEM) in the characterization of thin films and crystals, including techniques like high-resolution TEM (HRTEM) and selected area electron diffraction (SAED).
15 Explain the concept of stress and strain in thin films and their impact on material properties and device performance. Discuss the mechanisms of stress generation and techniques for stress measurement and control.

16 Derive the expression for the rate of nucleation in the classical nucleation theory. Discuss the factors influencing the nucleation rate and their importance in controlling the growth of thin films and crystals.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E09: Material Science

Time: 3 Hours **Max. Marks: 60**

SECTION-A

(Answer ANY FIVE questions. Each question carries 3 marks)

1. What are the main classifications of materials in materials science? Provide a brief description of each category.
2. Describe the significance of unit cells in understanding crystal structures and provide an example.
3. Define polymorphism and allotropy. Provide one example of each.
4. Explain the importance of crystallographic directions and planes in the study of crystalline solids.
5. Identify three common point defects in crystalline solids and describe their characteristics.
6. What is the stress-strain curve and why is it important?
7. Explain the difference between elastic and plastic deformation in materials.
8. What is the Lever Rule? How is it used in interpreting phase diagrams?

SECTION-B

(Answer ANY THREE questions. Each question carries 6 marks)

9. Outline a procedure to test and compare the stress-strain behavior, hardness, and toughness of two selected polymers.
10. Develop a strategy that includes the selection of materials, processing techniques, and testing methods to enhance fatigue resistance.
11. Design a detailed flowchart showing each stage of recrystallization, from initial deformation to final grain growth.
12. Formulate a plan to synthesize a composite material with specific mechanical properties. Propose a detailed plan including the selection of matrix and reinforcement materials, processing methods, and characterization techniques.
13. Create a phase diagram for an imaginary binary alloy system, indicating phases, solubility limits, and phase transformation points.

SECTION-C

(Answer ANY THREE questions. Each question carries 9 marks)

14. Evaluate the environmental consequences of using non-recyclable polymers. Discuss potential alternatives and their benefits.
15. Given a specific crystalline material, use crystallographic concepts to determine the optimal orientation for minimizing material defects during processing.

16. Evaluate the effectiveness of different strengthening mechanisms in metals. Compare and contrast various strengthening mechanisms in metals such as work hardening, alloying, and grain boundary strengthening.
17. Assess the role of smart materials in modern engineering applications. Provide a critical evaluation of the use of smart materials such as shape memory alloys and piezoelectrics in current engineering applications. Discuss their advantages and limitations.
18. In a binary alloy system, the composition of an alloy is 40% B and 60% A. At a certain temperature, the phases present are liquid (L) and solid (α). The composition of liquid phase is 70% B and 30% A, and the composition of solid phase is 20% B and 80% A. Determine the fraction of each phase.
19. Evaluate the potential of nanomaterials in enhancing the properties of traditional materials. Discuss how incorporating nanomaterials into traditional materials can improve their properties. Evaluate the challenges and potential solutions for integrating nanomaterials into manufacturing processes.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04E10: Biophysics and Bionanotechnology

Time: 3 Hours   Maximum Marks: 60

Section A (Answer any 5 questions, 3 marks each)

1 Define the term "biophysics" and explain its importance in understanding biological systems.
2 What is the role of lipids in the structure and function of biological membranes?
3 Briefly describe the principles of fluorescence spectroscopy and its applications in biophysical studies.
4 Explain the concept of nanopores and their potential applications in bionanotechnology.
5 What are biomimetic materials, and why are they important in bionanotechnology?
6 Differentiate between optical and electron microscopy techniques used in biophysical studies.

Section B (Answer any 3 questions, 6 marks each)

7 Describe the structure and function of proteins, including their folding and stability.
8 Explain the principles of X-ray crystallography and its applications in determining the structure of biomolecules.
9 Discuss the role of nanoparticles in drug delivery and their potential advantages over conventional drug delivery systems.
10 Implement the Metropolis algorithm in a programming language of your choice to simulate the folding of a simple protein structure.
11 Explain the principles of atomic force microscopy (AFM) and its applications in studying biological samples at the nanoscale.

Section C (Answer any 3 questions, 9 marks each)

12 Derive the relationship between the structure and function of enzymes and discuss the role of biophysical techniques in understanding enzyme catalysis.
13 Discuss the principles and applications of nano biosensors in the detection of biomolecules, pathogens, and environmental pollutants.
14 Explain the concept of molecular motors and their role in biological processes. Describe the biophysical techniques used to study their structure and function.
15 Describe the principles and applications of DNA origami in the design and fabrication of nanostructures for bionanotechnology.
16 Discuss the ethical and safety considerations in the development and use of bionanotechnology, including potential risks and regulatory frameworks.

Fourth Semester

MSc. Physics with Computational & Nano Science specialization Degree Examination

MSPHN04C19: Research Methodology & Experimental Techniques

Time: 3 Hours **Max. Marks: 60**

Section A

(Answer any 5. Each one carries 3 marks)

1. Mention the important characteristics of scientific research.
2. Give an account of any three sources of research ideas.
3. "Correlation does not imply causality". Do you agree with this statement? Justify.
4. What is "Rapid Communication"? Why is it important?
5. Define h-Index. Illustrate with an example.
6. What is the difference between the "guest authorship" and "ghost authorship"?

Section B

(Answer any 3. Each one carries 6 Marks)

7. What are the different factors to be considered while selecting a research topic?
8. Describe the commonly accepted elements of the scientific method.
9. Briefly discuss the various academic search engines.
10. With the help of a flow chart, explain the functions involved in the process of the publication of a research article.
11. Write a note on "intellectual property rights".

Section C

(Answer any 3. Each one carries 9 marks)

12. Define Hypothesis and discuss the various classification of hypotheses. What are the sources and characteristics of a good hypothesis?

13. Give an account of the principles and characteristics of experimental design. What do you mean by a “completely randomised design” and what are its advantages?
14. Discuss the various components of a research article.
15. What do you mean by “literature review”? What are the important sources of literature? Explain the components and framework of a literature review.
16. Define “plagiarism”. Discuss various methods to avoid plagiarism. Illustrate each with suitable examples.

Annexure I

Guidelines for the preparation of thesis on the research project

1. Arrangement of contents shall be as follows:

1. Cover page and title page
2. Bonafide certificate of the supervisor(s) *(internal and external, if any)*
3. Declaration by the student
4. Acknowledgement
5. Table of contents
6. List of tables
7. List of Figures
8. List of symbols, Abbreviations and Nomenclature
9. Chapters
10. Appendices
11. References
12. Certificate for Plagiarism check

2. Page dimension and typing instructions:

The dimension of the thesis on the project should be in A4 size. The thesis should be typed on bond paper and bound using a flexible cover of thick white art paper or spiral binding. The general text shall be typed in the font style 'Times New Roman' and font size 12. For major headings font size may be 16 and minor heading 14. Paragraphs should be arranged in justification with a margin of 1.25 each on top. Portrait orientation shall be there on the left and right of the page. The content of the report shall be around 50 to 80 pages.

3. Bonafide certificate shall be in the following format:

CERTIFICATE

This is to certify that the research project entitled ....(title) submitted to the Kannur University in partial fulfilment of the requirements of Post Graduate Degree in ....(subject), is a bonafide record of studies and work carried out by ....(Name of the student) under my supervision and guidance.

The student has successfully completed the pre-submission presentation for the M.Sc. Physics with Computational & Nano Science specialization Programme. The thesis has been uploaded to the institution's website, and the plagiarism check certificate has been appropriately attached to the thesis.

Office seal, Signature, name, designation and official address of the Supervisor.

Date:

4. Declaration by the student shall be in the following format:

DECLARATION

I..(Name of the candidate) hereby declare that this project titled…………..(title) is a bonafide record of studies and work carried out byme under the supervision of ....(Name, designation andofficial address of the supervisor), and that no part of this project, except the materialsgathered from scholarly writings, has been presented earlier for the award of any degree ordiploma or other similar title or recognition.

Date: Signature and Name of the student

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