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
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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)

PART – A

I & II Semester

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.) K. V. Murali,

Coordinator,

Ad Hoc-Committee for Curriculum and Syllabus Revision

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.

R1. The name of the Programme is **M.Sc. Physics with Computational and Nano Science specialization.**

R2. Eligibility for admission will be as per the rules laid down by the University from time to time.

R3. The curriculum for the Programme follows a choice-based credit semester system with Outcome Based Education and consists of four semesters.

R4. The medium of instruction for the Programme is English.

R5. 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.

R6. 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.

R7. 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.

R8. 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.

R9. 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:

$$CP = GP \times C$$

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.

R10. 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.

R11. 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.

R12. 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.

R13. 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.

R14. 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.

R15. 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.

R16. There shall be no improvement chance for the marks obtained in the project report.

R17. Institutional /Industrial visit is introduced for experiential learning.

R18. Information about the evaluation process, grading schemes, and examination formats are outlined in the general regulations.

R19. 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

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

Question Pattern (60 marks)

Part	Details of Questions		Marks	Level (Revised Bloom's Taxonomy)	Time to answer
A	No. of Questions in QP	6	15	1, 2 Remembering Understanding	30 minutes
	No. Questions to be answered	5			
	Marks for each question	3			
B	No. of Questions in QP	5	18	6 Creating	60 minutes
	No. Questions to be answered	3			
	Marks for each question	6			
C	No. of Questions in QP	5	27	3, 4, 5 Applying Analysing Evaluating	90 minutes
	No. Questions to be answered	3			
	Marks for each question	9			
Total Marks			60		180 minutes

Module-wise distribution of marks

Module	Module 1	Module 2	Module 3	Module 4
Minimum marks	15	15	15	15

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. Develop proficiency in setting up and conducting physics experiments using various scientific instruments.
2. Understand the principles of instrumentation and calibration processes to ensure accurate measurements.
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)

1. Determine the coefficient of viscosity of the given liquid by the oscillating disc method.
2. Determine the Young's modulus and Poisson's ratio of the material of the given bar by Koenig's method.
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. Determine Young's modulus, Poisson's ratio and bulk modulus of Pyrex/glass by forming Cornu's hyperbolic/elliptical fringes.
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.
6. Determine Stefan's constant of a black body using the given apparatus.
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.

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.
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.
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.
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.
12. Determine Young's Modulus, Rigidity modulus and Poisson's ratio of the material of a given wire by Searle's dynamical method.
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.
14. Determine the thermal expansion coefficient of a metal using single slit diffraction.

Cluster II

(At least 4 experiments should be done)

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

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.

5. Verify Heisenberg's uncertainty principle using a single slit diffraction pattern.
6. Measure the wavelengths of different lines in the hydrogen spectrum (visible region) and calculate the Rydberg constant using diffraction grating and spectrometer.
7. Determine the dielectric constants of different liquids using Colpitts oscillator.
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 (4th 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. Develop proficiency in setting up and conducting physics experiments using various scientific instruments.
2. Understand the principles of instrumentation and calibration processes to ensure accurate measurements.
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)

1. Determine the coefficient of viscosity of the given liquid by the oscillating disc method.
2. Determine the Young's modulus and Poisson's ratio of the material of the given bar by Koenig's method.
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. Determine Young's modulus, Poisson's ratio and bulk modulus of Pyrex/glass by forming Cornu's hyperbolic/elliptical fringes.
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.
6. Determine Stefan's constant of a black body using the given apparatus.
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.

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.
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.
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.
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.
12. Determine Young's Modulus, Rigidity modulus and Poisson's ratio of the material of a given wire by Searle's dynamical method.
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.
14. Determine the thermal expansion coefficient of a metal using single slit diffraction.

Cluster II

(At least 4 experiments should be done)

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

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.

5. Verify Heisenberg's uncertainty principle using a single slit diffraction pattern.
6. Measure the wavelengths of different lines in the hydrogen spectrum (visible region) and calculate the Rydberg constant using diffraction grating and spectrometer.
7. Determine the dielectric constants of different liquids using Colpitts oscillator.
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.

Cluster II

(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

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 $L = e^{\gamma t}\left[\frac{1}{2}m\dot{x}^2 - V(x)\right]$,

   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 $P = q\cot p$, $Q = \log\left(\frac{\sin p}{q}\right)$ 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 $f(x) = k,\ if\ 0 < x < a;\ and\ f(x) = 0,\ if\ x > a$.

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 $x^2y'' + xy' + (x^2 - n^2)y = 0$.
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

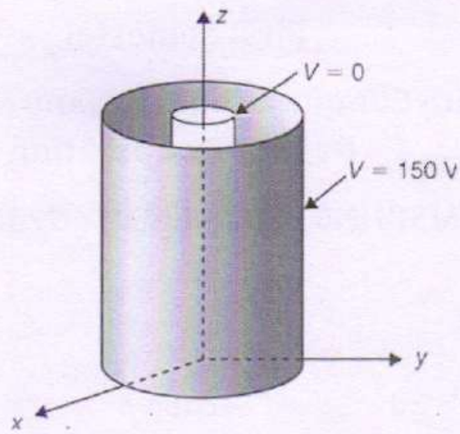
(Answer any 5, each question carries 3 marks)

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

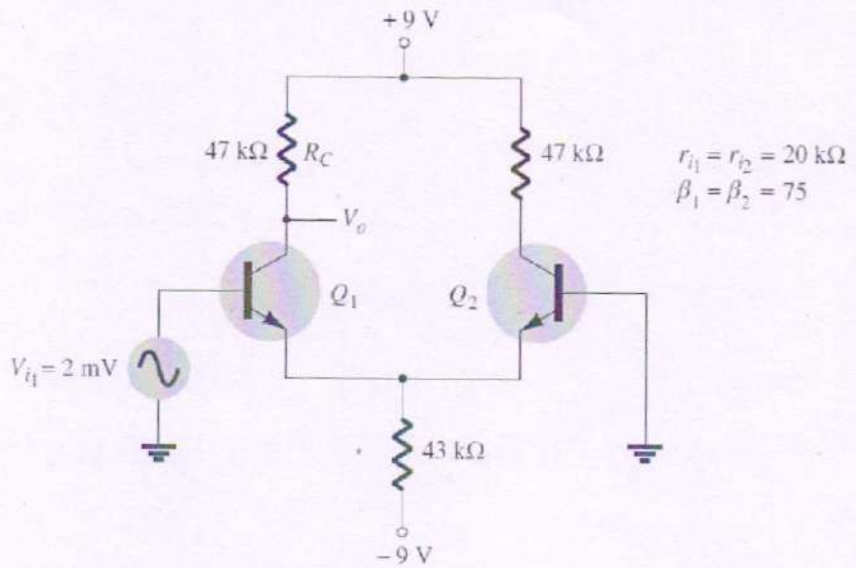
(Answer any 5, Each one carries 3 marks)

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

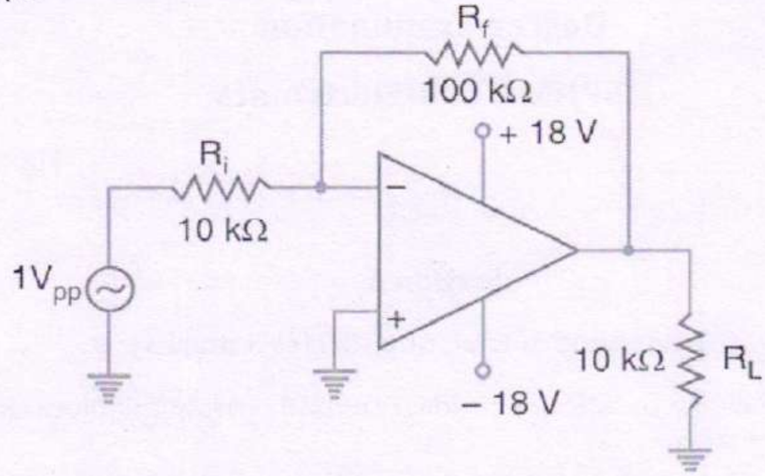
(Answer any 3, Each one carries 6 marks)

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 $2 \, sin \, sin \, x = x$ 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.

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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