K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

**SCHOOL OF BASIC AND APPLIED SCIENCES**

**Department of Physics**

# PROGRAMME HANDBOOK

**Physics Four year Under-Graduate(UG) Program**
**Framed according to the National Education Policy (NEP 2020)**
**(Academic Year 2023-27)**

**List of Contents**

## Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The K. R. Mangalam University visualizes all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Under-

Graduate cours. The department of physics presented four year under graduate programme B.Sc (H) physics with research according to the New Education Policy-2020. We have designed a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options for the duration of 2023-2027.

We are following Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" incorporating a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their interest.

The curriculum is aligned with the needs of the industry and the job market and is flexible enough to adapt to changing trends and technologies. It integrates cross-cutting issues relevant to professional ethics, gender, human values, environment and Sustainable Development Goals (SDGs). All academic programmes offered by the University focus on employability, entrepreneurship and skill development and their course syllabi are adequately revised to incorporate contemporary requirements based on feedback received from students, alumni, faculty, parents, employers, industry and academic experts

We are committed to implementing the National Education Policy (NEP) 2020 in its entirety, and to creating a more inclusive, holistic, and relevant education system that will prepare our students for the challenges of the 21st century. With the focus on Outcome-Based Education (OBE), our university is continuously evolving an innovative, flexible, and multidisciplinary curriculum, allowing students to explore a creative combination of credit-based courses in variegated disciplines along with value-addition courses, Indian Knowledge Systems, vocational courses, projects in community engagement and service, value education, environmental education, and acquiring skill sets, thereby designing their own learning trajectory.

All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of Physics and interdisciplinary areas. The courses will train students with sound theoretical and experimental knowledge that suits the need of academics and industry. The courses also offer ample skills to pursue research as career in the field of physics. The K. R. Mangalam University hopes the NEP-2020 approach of this four year under graduate programme B.Sc (H) physics with research will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

## 1. UNIVERSITY VISION AND MISSION

K.R. Mangalam University located on Sohna Road, Gurugram, is one of the fastest growing and most promising upcoming universities in India. It is a State Private University established in 2013 by an act of the legislature of the Haryana Government under Haryana Private Universities Act (Amendment) 8 of 2013.It is recognized by the UGC under Section 2f of the UGC Act, 1956. The primary aim of the University is to promote excellence in basic and professional education while upholding moral values.

KRMU offers sixty-eight Undergraduate, Postgraduate and Doctoral Degree programs across different disciplines. The group of educational units in the University promote education in the areas of Engineering& Technology, Legal Studies, Basic and Applied Sciences, Management Sciences, Commerce, Journalism and Mass Communication, Hotel Management and Catering Technology, Medical and Allied Sciences, Architecture and Planning, Agriculture, Fashion Designing, Humanities and Education. All the disciplines follow a well-defined curriculum design keeping in view the guidelines of UGC/AICTE and appropriate regulatory bodies like Council of Architecture (COA), Bar Council of India (BCI), Pharmacy Council of India (PCI), National Council for Teachers Education (NCTE) etc., wherever applicable. All courses are semester and credit based.

K.R. Mangalam University is the fastest-growing higher education institute in Gurugram, India. The University has been striving to fulfil its prime objective of transforming young lives through ground-breaking pedagogy, global collaborations, and world-class infrastructure. Recognized for its virtues of quality, equality, inclusiveness, sustainability, and professional ethics, KRMU is synonymous with academic excellence and innovation.

### 1.1. VISION

K.R Mangalam University aspires to become an internationally recognized institution of higher learning through excellence in inter-disciplinary education, research and innovation, preparing socially responsible life-long learners contributing to nation-building.

### 1.2 MISSION

1. Foster employability and entrepreneurship through futuristic curriculum and progressive pedagogy with cutting-edge technology.

2. Instill notion of lifelong learning through stimulating research, outcomes-based education and innovative thinking.

3. Integrate global needs and expectations through collaborative programs with premier universities, research centers, industries and professional bodies.

4. Enhance leadership qualities among the youth having understanding of ethical values and environmental realities.

## 2. SCHOOL OF BASIC AND APPLIED SCIENCES (SBAS)

### 2.1 About The School Basic and Applied Sciences

The SBAS imparts both teaching and research through its three Departments of Physics, Chemistry Mathematics and Forensic science.

SBAS imparts students disciplinary knowledge, enhances their skills and ability, motivating them to think ingeniously, helping them to act independently and take decisions accordingly in all their scientific pursuits and other endeavors. It strives to empower its students and faculty members to contribute for the development of society and Nation.

The faculty is in constant touch with various experts in the relevant fields and is willing to experiment with latest ideas in teaching and research.

## 3. SCHOOL VISION AND MISSION

### 3.1 School Vision

School of Basic and Applied Sciences intends for continuum growth as centre of advanced learning, research and innovation by disseminating analytical and scientific knowledge in the areas of basic and applied sciences by promoting interdisciplinary research and scientific acumen.

### 3.2 School Mission:

1. Enable students to be scientists/ academicians /entrepreneurs by accomplishing fundamental and advanced research in diverse areas of basic and applied sciences
2. Build strong associations with academic organizations/industries for knowledge creation, advancement, and application of scientific fervor
3. Create conducive environment for lifelong learning
4. Empower students to be socially responsible and ethically strong individuals through value-based science education
5. The school offers programmes in physics, mathematics, chemistry and forensic sciences.

## 4. INTRODUCTION TO THE BACHELOR OF SCIENCE (H) IN PHYSICS (B.SC.(H) PHYSICS)

The Bachelor of Science (Honors) in Physics (B.Sc.(H) Physics) is an undergraduate academic program designed to provide students with a comprehensive foundation in the fascinating world of physics. This program offers a rigorous and engaging curriculum that covers diverse areas such as classical mechanics, electromagnetism, quantum mechanics,

thermodynamics, and more. Students enrolled in this program will explore the fundamental principles that govern the universe, delve into complex problem-solving, and develop strong analytical and critical thinking skills. Through hands-on laboratory work and theoretical learning, students will gain practical experience and a deep understanding of scientific research methodologies. The B.Sc.(H) Physics program prepares students for exciting career opportunities in scientific research, technology, education, and various other fields that require a strong grasp of physics principles and applications

### 4.1. Nature of B.Sc.(H) Physics Programme

Taking the NEP-2020 as an opportunity to review our existing academic programs and redesign them for a more holistic, multidisciplinary and inclusive education, SBAS, K.R. Mangalam University is transforming its academic structure in a phased manner. Department of Physics is offering Four Year Undergraduate Degree programme B.Sc (H) physics with research with Multiple Entry- Multiple Exit option from the academic session 2023-24. Through multiple entry/exit option, students will be able to enter and exit the program at various stages. This course emphasized hands on practice, innovative thought process and project-based learning

### 4.2. Aims of B.Sc.(H) Physics Programme

The aims of the Bachelor of Science (Honors) in Physics (B.Sc.(H) Physics) program, in accordance with the National Education Policy (NEP), are multifaceted and comprehensive. The program aims to cultivate a strong foundation in physics principles and foster a deep understanding of the subject. It seeks to promote critical thinking, analytical skills, and problem-solving abilities among students, enabling them to address real-world challenges effectively. The B.Sc.(H) Physics program also encourages research-oriented thinking and provides opportunities for students to engage in scientific inquiry and exploration. By emphasizing hands-on laboratory work and practical applications, the program aims to equip students with the necessary skills for conducting experiments and analyzing data. Moreover, the program seeks to foster an interdisciplinary approach, enabling students to connect physics with other scientific disciplines and societal issues. Overall, the B.Sc.(H) Physics program aspires to produce well-rounded graduates with a passion for learning and a strong foundation in physics, ready to make significant contributions to the scientific community and society at large.

## 5. LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK IN BACHELOR OF PHYSICS (H) PROGRAMME (B.Sc.(H) Physics)

The Learning Outcome-Based Curriculum Framework in the Bachelor of Physics (H) Programme (B.Sc.(H) Physics) is designed to provide students with a comprehensive understanding of the fundamental principles and advanced concepts in physics. This framework is tailored to equip students with the necessary knowledge, skills, and abilities to excel in their academic pursuits and future careers in various scientific and technical fields. The curriculum focuses on achieving specific learning outcomes that are aligned with the

program's goals and objectives. These learning outcomes are aimed at fostering critical thinking, problem-solving skills, and analytical reasoning among students.

## 6. GRADUATE ATTRIBUTES

**GA1:** To demonstrate competence in discipline specific theoretical and practical Knowledge

**GA2:** To develop creativity and innovation

**GA3:** To enhance communication and interpersonal skills

**GA4:** To enable critical & logical thinking and investigative research attitude amongst students

**GA5:** To develop ethical values, teamwork and lifelong learning approach

## 7. QUALIFICATION DESCRIPTORS AND PROGRAMME DURATION

| Year | Objectives | Nature of Courses | Outcome |
|---|---|---|---|
| 1st year – (1st & 2nd Semesters) | Understanding and Exploration | [1] Discipline based CoreCourses<br>[2] Minor Discipline<br>[3] Value added course<br>[4] Open Elective<br>[5] Ability Enhancement Compulsory Courses<br>[6] Skill Enhancement | ➢ Understanding of Disciplines<br>➢ Language Competency<br>➢ Gaining perspective of context/Generic skills<br>➢ Basic skills related to handling and working with the instruments to pursue any vocation related to Lab Assistant |
| After one year Exit option with Certification | | | |

| | | | |
|---|---|---|---|
| 2nd Year - (3rd & 4th Semesters) | Focus and Immersion | [1] Discipline based CoreCourses<br>[2] Discipline specific elective Courses<br>[3] Minor Discipline<br>[4] Open Elective<br>[5] Skill Enhancement<br>[6] Ability Enhancement<br>[7] Value added course<br>[8] Internship | ➢ Understanding of disciplines Gaining perspective of context<br>➢ Skill sets for employability in data type setter, Development of various<br>➢ domains of mind & Personality |
| After Two years Exit Option with Diploma | | | |

| | | | |
|---|---|---|---|
| 3rd Year - (5th & 6th Semesters ) | Real time Learning | [1] Major Discipline Core<br>[2] Discipline specific elective Courses<br>[3] Minor Discipline<br>[4] Skill Enhancement<br>[5] Value added course<br>[6] Internship | ➢ In depth learning of major and minor disciplines, Skill sets foremployability.<br>➢ Exposure to discipline beyondthe chosen Subject<br>➢ Experiential learning/ Research. |
| Exit option with Bachelor Degree | | | |

| | | | |
|---|---|---|---|
| 4th Year –<br><br>(7th &8th Semesters) | Deeper Concentration | [1] Major Discipline Core<br>[2] Minor Discipline<br>[3] Research/ Project Work with Dissertation | ➢ Deeper and Advanced Learning of Major Discipline Foundation to pursue Doctoral Studies & Developing Research<br>➢ competencies |
| Bachelor Degree Honours with Research | | | |

## 8. PROGRAM EDUCATIONAL OBJECTIVES

**PEO-1:** Graduate will have significant prospects in the various fields like academics, industry, research organization, consultancy, defense and entrepreneurial pursuit at national and international level.

**PEO-2:** Graduate will achieve peer recognition as an individual or team member having specialized knowledge and expertise to identify, formulate, investigate, analyze and implement on the problems in physical sciences.

**PEO-3:** Graduate will have a solid foundation for academic excellence and quality leadership to meet the challenges in interdisciplinary and multi-disciplinary environment

**PEO-4:** Graduate will have ability to adopt, absorb and develop innovative and new technology in physical sciences and related areas through lifelong learning process.

**PEO-5:** Graduate will inculcate value system and work ethically in a multidisciplinary environment, to enhance the advancement in physics in general and contribute significantly through their critical thinking and scientific competence.

## 9. PROGRAM OUTCOMES (PO)

The B.Sc. (H) graduates should be able to:

PO1: Acquire fundamental understanding and conceptual knowledge of physics.
PO2: Understand application of basic concepts of physics.
PO3: Link Physics with related disciplines.
PO4: Acquire procedural knowledge for professional subjects.
PO5: Develop skills in related field of specialization.
PO6: Develop investigative skills and problem solving approach
PO7: Develop skills in Mathematical modeling.
PO8: Develop skills in performing analysis and interpretation of data.
PO9: Develop Technical Communication and ICT skills.
PO10: Demonstrate professional behavior with respect to attributes like objectivity, ethical values, self –reading etc

## 10. PROGRAM SPECIFIC OUTCOMES (PSOs)

The student graduating with the degree B.Sc. (H) Physics should be able to:

**PSO1:** Acquire a fundamental, systematic or coherent understanding of the academic field of Physics.
**PSO2:** Acquire procedural knowledge that creates different types of professional related to the disciplinary area of Physics.
**PSO3:** Acquire skills in areas related to one's specialization area within the disciplinary area of Physics and current and emerging development in the field of Physics.

**PSO4**: Demonstrate the ability to use skills in Physics and its related areas of technology

## MAPPING OF SCHOOL VISION, MISSION WITH PROGRAMME OUTCOMES (PO) AND PROGRAMME SPECIFIC OUTCOMES(PSO)

| **School Vision** | **School Mission** | **Programme Outcomes (PO)** | **Programme Specific Outcomes (PSO)** |
|---|---|---|---|
| School of Basic and Applied Sciences intends for continuum growth as centre of advanced learning, research and innovation by disseminating analytical and scientific knowledge in the areas of basic and applied sciences by promoting interdisciplinary research and scientific acumen. | **M 1** | **PO1, PO2, PO3, PO5, PO6, PO7, PO8, PO10** | **PSO1, PSO2, PSO3, PSO4** |
| | **M 2** | **O2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10** | **PSO1, PSO2, PSO3** |
| | **M 3** | **PO1, PO2, PO3, PO5, PO6, PO7, PO8, PO9, PO10** | **PSO1, PSO2, PSO3, PSO4** |
| | **M 4** | **PO3, PO4, PO5, PO6, PO9, PO10** | **PSO1, PSO2,** |
| | **M 5** | **PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10** | **PSO2, PSO3, PSO4** |

## 11. PROGRAMME DURATION

We have designed a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options for the duration of 2023-2027. The minimum period required for certificate in physics is one year, for Diploma in physics is two years, for B.Sc. degrss is three years and for the four year under graduate programme B.Sc (H) physics with research is four years.

## 12. CAREER OPTIONS

**Career Options: -** Opportunities exist in academics, research laboratories and administration besides all the opportunities applicable to any other graduate like UPSC examination's, defense services and other govt. jobs.

## 13. ELIGIBILITY CRITERIA

This course aims to impart basic and applied knowledge in physics with a view to produce good academics, researchers and professionals in the field.

**Eligibility Criteria: -** The student should have passed the 10+2 examination conducted by the Central Board of Secondary Education or equivalent examination from a recognized Board in Science stream with an aggregate of 50% or more.

## 14. CLASS TIMINGS

The classes will be held from Monday to Friday from 09:10 am to 04:10 pm.

## 15. TEACHING- LEARNING PROCESS

The School of Basic and Applied Sciences brings an attitudinal change among prospective teachers for their advancement into accountable agents of change in society. They are actively engaged in undertaking different activities such as school contact programs in various schools during their course with systematic support and feedback from the faculty. During this program, the student-teachers observe the school/classroom environments concerning infrastructure, equipment, teaching-learning materials, functioning, human resources, and organization of various activities. Such practices bring experiential learning by emphasizing reciprocal learning and reflection. The faculties foster and maintain a creative environment with a deep commitment to inculcate excellence in academics and contribute to student development through a focus on student-centric methods such as experiential learning, participative learning, problem-solving and ICT integration in the teaching-learning process.

## 16. ASSESSMENT METHODS

Both formative and summative assessments are integral part of the B.Sc. programme. Formative assessments such as class discussions, group activities, projects, quizzes, assignments and presentations are conducted throughout the teaching-learning process, enabling teachers to monitor student progress continuously. Teachers provide oral or written feedback, engage in one-on-one discussions, and use rubrics and checklists to communicate student performance. Summative assessments such as Term End Examination, viva voce for

project work, research dissertations and performance evaluations are conducted after the completion of the course.

## 17. MINIMUM ACCEPTABLE LEVEL OF ACADEMIC STANDARDS

The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of the assessment process of the student's performance is indicated in Table 1.

**Table 1**

| **arks Range (%)** | **tter Grade** | **ade Points** | **scription of the Grade** |
|---|---|---|---|
| >90 | | 0 | tstanding |
| -90 | | | xcellent |
| -80 | | | ry Good |
| -70 | | | od |
| -60 | | | ove Average |
| -55 | | | erage |
| -50 | | | ss |
| 0 | | | l |
| | | | sent |
| marks≥ 50 | | | tisfactory |
| marks <50 | | | satisfactory |
| | | | thdrawal |

## 18. PROGRAMME STRUCTURE

**Four-Year B.Sc.(H) Physics with research programme at a glance**

| | Sem I | Sem II | Sem III | Sem IV | Sem V | Sem VI | Sem VII | Sem VIII | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Courses** | 7 | 8 | 8 | 8 | 7 | 8 | 5 | 2 | 53 |
| **Credits** | 20 | 23 | 25 | 21 | 20 | 22 | 17 | 16 | 164 |

**19. Scheme of Studies for B.Sc. (Hons.) Physics with Research- Nano Sciences stream: Year 2023-2028 (Scheme of Studies) FYUDP**

| First year : Odd Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH101 | Mathematical Physics I | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH103 | Electricity and Magnetism | 4 | 0 | 0 | 4 |
| 3 | Major-DSC | SCPH151 | Electricity and Magnetism LAB | 0 | 0 | 2 | 1 |
| 4 | AEC-I | AEC001 | Communicative English-I | 3 | 0 | 0 | 3 |
| 5 | VAC-I | | Value Added Course ( EVS+Disaster)through Moodle | 2 | 0 | 0 | 2 |
| 6 | SEC-I | SEC015 | Basic Instrumentation Skills | 2 | 0 | 0 | 2 |
| 7 | Minor1 | UNS101 | Study of Materials | 4 | 0 | 0 | 4 |
| | | | TOTAL | | | | 20 |

| First year : Even Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH102 | Mathematical Physics II | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH104 | Mechanics | 4 | 0 | 0 | 4 |
| 3 | Major-DSC | SCPH152 | Mechanics Lab | 0 | 0 | 2 | 1 |
| 4 | AEC-II | AEC002 | Communicative English-II | 3 | 0 | 0 | 3 |
| 5 | VAC-II | | Value Added Course (Based on Extension Activity) | 2 | 0 | 0 | 2 |
| 6 | Open Elective/Generic Elective-I | | | 3 | 0 | 0 | 3 |
| 7 | SEC-II | SEC016 | Physics Workshop Skill | 0 | 0 | 2 | 2 |
| 8 | Minor2 | UNS102 | Elements of Nanosciences and nanomaterials | 4 | 0 | 0 | 4 |
| | | SIPH001 | Summer Internship /Project | | | | |
| | | | TOTAL | | | | 23 |

| Second year : Odd Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | DSCT5 | SCPH201 | Mathematical Physics III | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH203 | Solid State Physics | 4 | 0 | 0 | 4 |
| 3 | Major-DSE | SCPH205 | Introduction of Nanochemistry and Applications | 4 | 0 | 0 | 4 |
| | | SCPH207 | Green Processes Of Chemistry | 4 | 0 | 0 | |
| 4 | Major-DSC | SCPH251 | Solid State Physics Lab | 0 | 0 | 2 | 1 |
| 5 | Minor 3 | UNS103 | Nanostructured materials | 4 | 0 | 0 | 4 |
| 6 | AEC-III | AEC003 | New Age Life Skills-III | 3 | 0 | 0 | 3 |
| 7 | Open Elective/Generic Elective-I | | Select one course from a basket of course | 3 | 0 | 0 | 3 |
| 8 | Summer Internship /Project | SIPH001 | Evaluation of Summer Internship /Project | 2 | 0 | 0 | 2 |
| Total | | | | | | | 25 |

| Second year : Even Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH202 | Modern Physics | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH204 | Waves and Optics | 4 | 0 | 0 | 4 |
| 3 | Major-DSC | SCPH252 | Waves and Optics Lab | 0 | 0 | 2 | 1 |
| 4 | Open Elective/Generic Elective-III | | Select one course from a basket of course | 3 | 0 | 0 | 3 |
| 5 | VAC-III | | Select one course from a basket of course | 2 | 0 | 0 | 2 |
| 6 | SEC-III | SEC017 | Documentation using Latex | 0 | 0 | 2 | 2 |
| 7 | Minor 4 | UNS104 | Crystallography | 4 | 0 | 0 | 4 |
| 8 | Minor 5 | UNS105 | Crystallography Lab | 0 | 0 | 2 | 1 |
| | | SIPH002 | Summer Internship /Project | | | | |
| TOTAL | | | | | | | 21 |

| IIIrd year : Odd Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH301 | Quantum mechanics and applications | 4 | 0 | 0 | 4 |
| | Major-DSC | SCPH303 | Digital Systems And Applications | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH351 | Digital Systems And Applications Lab | 0 | 0 | 2 | 1 |
| 3 | Minor6 | UNS106 | Synthesis of Nanomaterials-I | 4 | 0 | 0 | 4 |
| 4 | Minor7 | UNS107 | Synthesis of Nanomaterials-I lab | 0 | 0 | 2 | 1 |
| 5 | DSE2 | SCPH305 | Applied Optics | 4 | 0 | 0 | 4 |
| | | SCPH307 | Laser Fundamentals | 4 | 0 | 0 | |
| 6 | Summer Internship/Project | SIPH002 | Evaluation of Summer Internship /Project | 2 | 0 | 0 | 2 |
| TOTAL | | | | | | | 20 |

| IIIrd year Even SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH302 | Analog Systems and Applications | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH352 | Analog Systems and Applications Lab | 0 | 0 | 2 | 1 |
| 3 | Major-DSC | SCPH304 | Themodynamics and Statistical Mechanics | 4 | 0 | 0 | 4 |
| 4 | Major-DSC | SCPH306 | Electromagnetic theory | 4 | 0 | 0 | 4 |
| 5 | Minor8 | UNS108 | Characterisation techniques of nanomaterials | 4 | 0 | 0 | 4 |
| 6 | Minor9 | UNS109 | Characterisation techniques of nanomaterials Lab | 0 | 0 | 2 | 1 |
| 7 | VAC-IV | | Select one course from a basket of course | 2 | 0 | 0 | 2 |
| 8 | SEC-IV | SEC018 | Electrical circuits and network skills | 0 | 0 | 2 | 2 |
| TOTAL | | | | | | | 22 |

| IV$^{th}$ year : Odd Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH401 | Nuclear Physics | 4 | 0 | 0 | 4 |
| 2 | Major-DSC | SCPH403 | Classical dynamics | 4 | 0 | 0 | 4 |
| 3 | Major-DSC | SCCH401 | Research Methodology | 4 | 0 | 0 | 4 |
| 4 | Minor10 | UNS110 | Synthesis of Nanomaterials-II | 4 | 0 | 0 | 4 |
| 5 | Minor11 | UNS111 | Synthesis of Nanomaterials-II lab | 0 | 0 | 2 | 1 |
| Total | | | | | | | 17 |

| IVth year : Even SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No. | TYPE OF COURSE | COURSE CODE | COURSE TITLE | L | T | P | C |
| 1 | Major-DSC | SCPH402 | Atomic, and Molecular Physics | 4 | 0 | 0 | 4 |
| 2 | | | Research Project-II | | | | 12 |
| Total | | | | | | | 16 |

| Summary Sheet B.Sc (H) Physics with Research -Nano Sciences | | | | |
|---|---|---|---|---|
| **S. No.** | **Nature of Papers** | **Total No. of Papers** | **Credits (Theory+Practical)** | **TOTAL CREDITS** |
| **1** | Major-DSC | 23 | (4+1) | 74 |
| | Major-DSE (Discipline Specific Electives) Papers | 2 | 4 | 8 |
| **2** | Minor | 11 | 32 | 32 |
| **3** | Open elective | 3 | 3 | 9 |
| **4** | Ability Enhancement Courses | 3 | 3 | 9 |
| **5** | Skill Enhancement Courses | 4 | 2 | 8 |
| **6** | Value Added Courses | 4 | 2 | 8 |
| 7 | Summer Internship/Project | 2 | 2 | 4 |
| 8 | Research Project | 1 | 12 | 12 |
| **Total Papers/Credits** | | | | **164** |

# Syllabus of B.Sc. (Hons.) Physics

## Semester I

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH101 | Mathematical Physics I | 4 |
| 2 | SCPH103 | Electricity and Magnetism | 4 |
| 3 | SCPH151 | Electricity and Magnetism LAB | 1 |
| 4 | AEC001 | Communicative English-I | 3 |
| 5 | | Value Added Course ( EVS+Disaster) through Moodle | 2 |
| 6 | SEC015 | Basic Instrumentation Skills | 2 |
| 7 | UNS101 | Study of Materials | 4 |
| | | TOTAL | 20 |

| SCPH101 | Mathematical Physics-I | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Calculus | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To make them learn about the calculus and its applications.
2. To enable them to use vector calculus for different applications.
3. To give knowledge of vector differentiation, integration.
4. To impart knowledge about orthogonal curvilinear coordinate, probability and Dirac delta function and its properties.

**Course Outcomes**

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

**CO1:** Apply calculus principles and differential equations to solve mathematical and real-world problems.

**CO2:** Demonstrate proficiency in vector calculus techniques for functions of multiple variables and constrained maximization.

**CO3:** Analyze and compute directional derivatives, divergence, curl, and perform line, surface, and volume integrals of vector fields.

**CO4:** Utilize orthogonal curvilinear coordinates and probability distribution functions for practical applications in various contexts.

**Catalog Description**

This course aims to demonstrate the use of mathematical techniques in solving problems in Physics and to provide a deeper understanding of the mathematics underpinning theoretical physics. The course is intended to develop the concepts of vector calculus and its applications. Emphasis will be on illustrative examples from Physics and Engineering.

**Course Content**

**UNIT-I** **14 Lectures**

**Calculus:**

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Intuitive ideas of continuous, differentiable, etc. Approximation: Taylor and binomial series (statements only).
First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

**UNIT-II** **14 Lectures**

**Vector Calculus:**

**Calculus of functions of more than one variable**: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

**Recapitulation of vector**s: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

**UNIT-III** **14 Lectures**

**Vector Differentiation**: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

**Vector Integration:** Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

**UNIT-IV** **12 Lectures**

**Orthogonal Curvilinear Coordinates:**

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

**Introduction to probability:**

Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance

**Text Books:**

TB1:Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.

TB2:Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

TB3:Mathematical Physics, Goswami, 1st edition, Cengage Learning

TB4:Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

TB5:Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.

**Reference Books:**

RB1:Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.

RB2:An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning

RB3:Differential Equations, George F. Simmons, 2007, McGraw Hill.

RB4:Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

RB5:Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book

RB6:Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.

Open Educational Resources (OER)

OER1: https://www.youtube.com/playlist?list=PLZHQObOWTQDNPOjrT6KVlfJuKtYTftqH6

OER2: https://www.youtube.com/watch?v=GLs0nXZBUYk

OER3: https://archive.nptel.ac.in/courses/111/105/111105122/

OER4: https://www.youtube.com/watch?v=KZzAFX54DWs

OER5: https://archive.nptel.ac.in/courses/111/102/111102111/

## Assessment & Evaluation

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

### Programme And Course Mapping

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SCPH101** Mathematical Physics-I | **CO1** | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 2 |
| | **CO2** | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 3 | 2 | 3 |
| | **CO3** | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 1 |
| | **CO4** | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Unit-I: Calculus - Recapitulation and Differentiation | TB1, OER1 | Lectures, Discussions |
| 2 | Unit-I: Calculus - Approximation and Taylor Series | TB1, OER1 | Online Tutorials, Quizzes |
| 3 | Unit-I: First Order Differential Equations | TB1, OER2 | Problem-Solving Sessions |
| 4 | Unit-I: First Order Differential Equations (cont.) | TB1, OER2 | Group Projects |
| 5 | Unit-II: Vector Calculus - Partial Derivatives | TB1, OER2 | Demonstrations, |

| | | | |
|---|---|---|---|
| | | | Labs |
| 6 | Unit-II: Vector Calculus - Exact Differentials | TB1, OER2 | Guest Lectures |
| 7 | Unit-II: Vector Calculus - Constrained Maximization | TB1, OER3 | Practical Exercises |
| 8 | Unit-III: Vector Differentiation - Gradient | TB1, OER3 | |
| 9 | Unit-III: Vector Differentiation - Divergence | TB1, OER3 | Virtual Simulations |
| 10 | Unit-III: Vector Integration - Ordinary Integrals | TB1, OER3 | Peer Presentations |
| 11 | Unit-III: Vector Integration - Multiple Integrals | TB1, OER3 | Problem-Based Learning |
| 12 | Unit-III: Vector Integration - Flux and Divergence Theorems | TB1, OER4 | Case Studies |
| 13 | Unit-III: Vector Integration - Green's and Stokes' Theorems | TB1, OER4 | Interactive Workshops |
| 14 | Unit-IV: Orthogonal Curvilinear Coordinates and Introduction to Probability | TB1, OER5 | Revision Lectures |

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Calculus |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | **Vector calculus and its applications, analytical reasoning,** |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Vector calculus |
| Local | - |
| Regional | - |
| National | - |
| Global | **Disciplinary knowledge, use of mathematical techniques in solving problems in physics and engineering** |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Vector differentiation & integration |
| Local | - |

| | |
|---|---|
| Regional | - |
| National | |
| Global | **Disciplinary knowledge, use of mathematical techniques in solving problems in physics and engineering** |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Orthogonal Curvilinear Co-Ordinates & Probability |
| Local | - |
| Regional | - |
| National | - |
| Global | **Scientific reasoning, equations encountered in physics and engineering** |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | **(skills for decent work, safe and inclusive learning environments)** |
| Nep 2020 | **Towards a more holistic and multidisciplinary education**<br>**Promoting high-quality research** |
| Poe/4th IR | **Use of software and simulations**<br>**Projects and group discussion** |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Apply calculus principles and differential equations to solve mathematical and real-world problems. | - Lectures<br>- Presentations | ➢ Presentations and class discussions.<br>➢ Assignments and |

| | | | |
|---|---|---|---|
| | | - Discussions | class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Demonstrate proficiency in vector calculus techniques for functions of multiple variables and constrained maximization. | - Problem-Solving | |
| | | - Discussions | |
| | | - Case Studies | |
| III | Analyze and compute directional derivatives, gradient, divergence, and curl of scalar and vector fields. | - Lecture | |
| | | - Guest Lectures | |
| | | - Practical Exercises | |
| IV | Utilize orthogonal curvilinear coordinates and probability distribution functions for practical applications. | - Guest Lectures | |
| | | -Demonstrations | |
| | | - Problem-Solving | |

| **SCPH103** | Electricity and Magnetism | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of Physics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

1. The abstraction from forces to fields using the examples of the electric and magnetic fields, with some applications
2. To learn how charges behave through electric circuits.
3. Consolidate the understanding of fundamental concepts in Electricity and Magnetism more rigorously as needed for further studies in physics, engineering and technology.
4. Expand and exercise the students' physical intuition and thinking process through the understanding of the theory and application of this knowledge to the solution of practical problems

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Apply Gauss' Law and understand the conservative nature of electrostatic fields, and calculate electric potential and electric field for charge distributions with various symmetries.

CO2: Utilize special techniques like the Method of Images to calculate potential and field in the presence of infinite sheets and spheres maintained at constant potential, and analyze electric fields in matter including polarization, displacement vector, and dielectric properties.

CO3: Analyze magnetic fields, magnetic force, and torque on current elements, and apply Ampere's Circuital Law to solenoids and toroids, as well as calculate magnetic properties of matter such as magnetization, magnetic intensity, susceptibility, and hysteresis.

CO4: Understand electromagnetic induction, Faraday's Law, self and mutual inductance, and apply reciprocity theorem and Maxwell's Equations to analyze energy stored in magnetic fields, and

comprehend concepts like charge conservation and displacement current.

**Catalog Description**

This course imparts the basic concepts of Physics. The course is design to point to a plausible physical origin of simple electromagnetic phenomena in nature, based on what the candidate has learned in the course about fundamental laws and concepts in electricity and magnetism. The course of Electricity and Magnetism help organizing the data in variety of ways to solve the problem efficiently. The course is focused on theoretical discussions of Electricity and Magnetism and applications of discussed phenomenon. It also discusses about daily life physics like magnetism, current etc.

**Course Content**

**Unit I: 13 Lecture hours**

**Electrostatics:**

Electric field & Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential.

Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor.

**Unit II: 14 Lecture hours**

**Special techniques for the calculation of Potential and Field:** The Method of Images is applied to a system of a point charge and finite continuous charge distribution (line charge and surface charge) in the presence of (i) a Plane infinite sheet maintained at constant potential, and (ii) a Sphere maintained at constant potential.

**Electric Field in Matter**: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field.

**Unit III: 13 Lecture hours**

**Magnetostatics :** Magnetic Field: Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid.

Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

**Unit IV: 14 Lecture hours**

**Magnetic Properties of Matter**: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

**Electrodynamics**

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

**Text Books**

1. Physics for Scientists and Engineers (6th Ed.), Raymond A. Serway and John W. Jewett, Thomson Brooks (2004).

2. Engineering Physics Theory and Practical, A. K. Katiyar and C. K. Pandey, Wiley (2015)

**Reference Books/Materials**

1. Introduction to Electrodynamics (3rd Indian reprint), D.J. Griffiths,., Pearson Education (2003).
**2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.**

**Open Educational Resources (OER)**

**https://www.youtube.com/watch?v=dGYCwt2Nqas**

**https://www.youtube.com/watch?v=qjsZTBZd1Ms**

**https://www.youtube.com/watch?v=KGTZPTnZBFE**

**https://www.youtube.com/watch?v=hJD8ywGrXks&vl=en**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH103 Electricity and Magnetism | **CO1** | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 |
| | **CO2** | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | **CO3** | 3 | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| | **CO4** | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 3 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

# Teaching Plan:

| **Week** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ OER** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Electrostatics: Electric Field & Electric Field Lines | TB1, RB2 | Lectures, Discussions |
| 2 | Electrostatics: Electric Flux & Gauss' Law | TB1, RB2 | Online Tutorials, Quizzes |

| | | | |
|---|---|---|---|
| 3 | Electrostatics: Charge Distributions with Symmetry & Conservative Nature of Electrostatic Field | TB1, RB2 | Problem-Solving Sessions |
| 4 | Electrostatics: Electrostatic Potential & Laplace's and Poisson Equations | TB1, RB2 | Group Projects |
| 5 | Electrostatics: Potential and Electric Field of a Dipole | TB1, RB2 | Demonstrations, Labs |
| 6 | Electrostatics: Force and Torque on a Dipole & Capacitance of Charged Conductors | TB1, RB2 | Guest Lectures |
| 7 | Electrostatics: Parallel-Plate Capacitor & Capacitance of an Isolated Conductor | TB1, RB2 | Practical Exercises |
| 8 | Special Techniques for the Calculation of Potential and Field | TB1, RB2 | Hands-on Activities |
| 9 | Electric Field in Matter: Polarization in Matter & Bound Charges | TB1, RB2 | Virtual Simulations |
| 10 | Electric Field in Matter: Field inside a Dielectric & Gauss' Law in the presence of Dielectrics | TB1, RB2 | Peer Presentations |
| 11 | Electric Field in Matter: Boundary Conditions for D & Linear Dielectrics | TB1, RB2 | Problem-Based Learning |
| 12 | Electric Field in Matter: Electric Susceptibility & Dielectric Constant | TB1, RB2 | Case Studies |
| 13 | Magnetostatics: Magnetic Field & Magnetic Force between Current Elements | TB1, RB2 | Revision Lectures |
| 14 | Magnetostatics: Biot-Savart's Law & Current Loop as a Magnetic Dipole | TB1, RB2 | Revision Lectures |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning | Assessment Task Methods |
|---|---|---|---|
| I | Apply Gauss' Law to calculate electric flux and understand the conservative nature of electrostatic fields.<br>Calculate electric potential and field for different charge distributions. | - Lectures<br>- Presentations<br>- Problem-Solving | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations. |
| II | Utilize special techniques like the Method of Images to calculate potential and field in | - Lecture | |

| | | | |
|---|---|---|---|
| | different configurations.<br>Analyze electric fields in matter, polarization, and displacement vector. | - Discussions | ➢ End-term examinations |
| | | - Problem-Solving | |
| III | Utilize Biot-Savart's Law to calculate magnetic fields and analyze magnetic force between current elements.<br>Understand magnetic fields, force, torque, and magnetic properties of matter. | - Lecture | |
| | | - Guest Lectures | |
| | | - Practical Exercises | |
| IV | Apply Ampere's Circuital Law to solenoids and toroids and calculate the magnetic field for a current loop.<br>Understand electromagnetic induction, Faraday's Law, self and mutual inductance, and apply Maxwell's Equations. | - Guest Lectures | |
| | | - Demonstrations | |
| | | - Problem-Solving | |

| **SCPH151** | Electricity and Magnetism Lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of Physics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

1. Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer. To learn how charges behave through electric circuits.
2. Sessions on the review of scientific laboratory report writing, and on experimental data analysis.
3. Expand and exercise the students' physical intuition and thinking process through the experiments.
4. Interpretation of experimental data

**Course Outcomes**

On completion of this course, the students will be able to

CO1. Acquire fundamental knowledge of laboratory instruments and their uses.

CO2. Better insight about data collection techniques.

CO3. Better understanding of data interpretation and error analysis.

CO4. Acquire knowledge about the techniques related data analysis and curve fitting.

**Catalog Description**

This course imparts the basic concepts of experimental physics. The course is design to give knowledge how to use basic instruments in laboratory and laboratory experiment protocols. The main focus is on data collection techniques and the data interpretation. For this purpose a series of experiments have

been set. The difficulty level of experiments is set easy to moderate level due to introductory physics.

**Course Content**

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

**Text Books** [TB]

1. Physics for Scientists and Engineers (6th Ed.), Raymond A. Serway and John W. Jewett, Thomson Brooks (2004).
2. Engineering Physics Theory and Practical, A. K. Katiyar and C. K. Pandey, Wiley (2015).

**Reference Books/Materials** [RB]

1. Introduction to Electrodynamics (3rd Indian reprint), D.J. Griffiths,., Pearson Education (2003).
2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw

**Open Educational Resources (OER)**

1. phet.colorado.edu
2. **https://www.youtube.com/watch?v=dGYCwt2Nqas**

## Assessment & Evaluation

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SCPH152** Mechanics Lab | **CO1** | **3** | **1** | | | | | | | | | **3** | **1** | | |
| | **CO2** | | **3** | **2** | | | | | | | | | **2** | | |
| | **CO3** | | | **3** | | **2** | **1** | | | | | | | **3** | **1** |
| | **CO4** | | | | **3** | | | **2** | **3** | **1** | | | | | |

1=lightly mapped 2= moderately mapped 3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Electric field |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of fundamental concepts in electricity |
| Employability | Solving problems involving electric circuits and their behavior |
| Entrepreneurship | - |
| Skill development | Solving problems involving magnetic circuits and their behavior |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Electrostatic energy of system of charges, dielectric properties of matter give heading of the unit here (if applicable) |
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of fundamental concepts in magnetism |
| Employability | Solving problems involving magnetic circuits and their behavior |
| Entrepreneurship | - |
| Skill development | Solving problems involving magnetic circuits and their behavior |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Magnetic field, magnetic properties of matter |
| Local | - |
| Regional | - |
| National | - |
| Global | Applications of electricity and magnetism |

| | |
|---|---|
| Employability | Application of electricity and magnetism in daily life |
| Entrepreneurship | - |
| Skill development | Application of electricity and magnetism in daily life |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Electromagnetic induction, electrical circuits, network theorems, ballistic galvanometer |
| Local | - |
| Regional | - |
| National | - |
| Global | Scientific reasoning |
| Employability | Application of electricity and magnetism in daily life |
| Entrepreneurship | - |
| Skill development | Application of electricity and magnetism in daily life |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |

# Teaching Plan:

| Week | Topic/Experiment No. | [TB]/ [RB]/ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Experiment 1<br>Use of Multimeter for measuring electrical quantities | OER1 | - Introduction to electrical measurements and multimeters.<br>Hands-on practice with multimeters.<br>Demonstration of various measurements. |
| 2 | Experiment 2<br>Study of characteristics of a series RC Circuit | OER1 | - Introduction to RC circuits and their behavior.<br>Practical setup and measurements.<br>Data collection and analysis. |
| 3 | Experiment 3<br>Determination of unknown Low Resistance using Potentiometer | OER1 | Explanation of potentiometer and its applications.Experiment setup and measurements.Calculation of unknown resistance. |
| 4 | Experiment 4<br>Determination of unknown Low Resistance using Carey Foster’s Bridge | OER1 | Introduction to Carey Foster's Bridge and working.<br>Practical setup and measurements.<br>Calculation of unknown resistance. |
| 5 | Experiment 5<br>Comparison of capacitances using De’Sauty’s bridge | OER1 | De’Sauty’s bridge and its principle.<br>Experimental setup and measurements.<br>Comparison of capacitances. |
| 6 | Experiment 6<br>Measurement of field strength B and its variation in a solenoid | OER1 | Introduction to magnetic fields and solenoids. Experimental setup and measurements of dB/dx.<br>Data analysis. |

| | | | |
|---|---|---|---|
| 7 | Experiment 7<br>Verification of Thevenin and Norton theorems | OER1 | Explanation of Thevenin and Norton theorems. Practical verification of the theorems.Data collection and analysis. |
| 8 | Experiment 8<br>Verification of Superposition and Maximum power transfer theorems | OER1 | Introduction to superposition and maximum power transfer.<br>Practical verification of the theorems.<br>Data collection and analysis. |
| 9 | Experiment 9<br>Determination of self inductance of a coil by Anderson's bridge | OER1 | Anderson's bridge setup and working.<br>Experimental measurements of self inductance.<br>Calculation of self inductance. |
| 10 | Experiment 10<br>Study of response curve of a Series LCR circuit | OER1 | Series LCR circuit behavior and response.<br>Practical setup and measurements.<br>Calculation of resonant frequency, impedance, Q-factor. |
| 11 | Experiment 11<br>Study of response curve of a parallel LCR circuit | OER1 | Parallel LCR circuit response and behavior. Practical setup and measurements. Calculation of anti-resonant frequency and Q-factor. |
| 12 | Experiment 12<br>Measurement of charge and current sensitivity of Ballistic Galvanometer | OER1 | Ballistic galvanometer and its principles.<br>Experiment setup for charge and current sensitivity.<br>Data collection and analysis. |
| 13 | Experiment 13<br>Determination of high resistance by leakage method using Ballistic Galvanometer | OER1 | Leakage method using ballistic galvanometer.<br>Practical setup and measurements.<br>Calculation of high resistance. |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Use a multimeter for measuring various electrical quantities. | - Hands-on practice<br>- Presentations<br>- Discussions | ➢ Presentations and class discussions.<br>➢ Lab reports and comparison with theoretical values<br>➢ Assignments and class tests.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Study characteristics of electrical circuits and verify theorems. | - Problem-Solving Sessions<br>- Discussions<br>- Case Studies | |
| III | Determine electrical parameters using various measurement techniques. | - Lecture<br>- Guest Lectures<br>- Practical Exercises | |
| IV | Apply concepts of electromagnetism and | - Guest Lectures<br>- | |

| | | | |
|---|---|---|---|
| | inductance in practical scenarios. | Demonstrations | |
| | | - Problem-Solving Sessions | |

| **AEC001** | New Age Life Skills-I | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | -- | | | | |

| SEC015 | Basic Instrumentation Skills | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 2 |
| **Total Contact Hours** | 27 | | | | |
| **Pre-requisites/Exposure** | Basics of Physics | | | | |
| **Co-requisites** | Basics of Electronics | | | | |

**Course Objectives**

1. Dedicated demonstration cum hands on sessions on the construction, functioning and uses of different measuring Instruments such as Voltmeter, Ammeter, Multimeter, CRO, Function Generator etc.
2. To learn difference between analog and digital meters.
3. Expand and exercise the students' physical intuition and thinking process through the experiments.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Understand the principles and specifications of measurement instruments.

CO2: Analyze the working principles of Analog and digital voltmeter, ammeter and multimeter.

CO3: Apply CROs and DSOs for voltage measurement and analysis.

**Course Description**

This course is to give exposure with various aspects of instruments and their usage through hands-on mode. Importance of measurement is explained along with the working of various measuring instruments. For this purpose, a series of experiments have been set. Experiments listed below are to be done in continuation of the topics.

.

**UNIT-I** **5 Lectures**

**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Specifications of a multimeter and their significance.

**Unit-II** **10 Lectures**

**Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only).

Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

**UNIT-III** **12 Lectures**

**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

**Text Books:**


1. Text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.


**Reference Books:**


1. Logic circuit design, Shimon P. Vingron, 2012, Springer.
2. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
3. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
4. Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
5. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.


**Open Educational Resources (OER)**

**https://www.youtube.com/watch?v=kxKOU3hmNug**

**https://www.youtube.com/watch?app=desktop&v=dGtwItnYYqk**

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEC015 Basic Instrumentation Skills | CO1 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 |
| | CO2 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| | CO3 | 3 | 3 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Basic of measurement |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of construction of standard laboratory instruments |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Understanding of various analog and digital instruments |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Cathode ray oscilloscope |
| Local | - |
| Regional | - |
| National | - |
| Global | Differentiation between working of digital and analog instruments |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Understanding of various analog and digital instruments, |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |

| | |
|---|---|
| Unit iii | Signal generators and analysis instruments |
| Local | - |
| Regional | - |
| National | - |
| Global | Using cathode ray oscilloscope (CRO) and function generators |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Learning data fitting |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Digital instruments |
| Local | - |
| Regional | - |
| National | - |
| Global | Related to data fitting and curve analysis |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Concept of accuracy, precision, and sensitivity in measurements |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | SDG<br>Promoting high-quality research |
| Poe/4th IR | Hands on experience. |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Multimeter | TB1, OER1 | Lectures, Discussions |
| 2 | Electronic Voltmeter | TB1, OER1 | Online Tutorials, Quizzes |
| 3 | AC Millivoltmeter | TB1, OER1 | Problem-Solving Sessions |
| 4 | Cathode Ray Oscilloscope | TB1, OER2 | Demonstrations, Labs |
| 5 | Time Base Operation | TB1, OER2 | Lectures, Discussions |
| 6 | Front Panel Controls | TB1, OER2 | Demonstrations, Labs |
| 7 | Digital Storage Oscilloscope | TB1, OER2 | Lectures, Discussions |
| 8 | Construction of CRT | TB1, OER2 | Lectures, Discussions |
| 9 | Time Base Operation | TB1, OER2 | Lectures, Discussions |
| 10 | Introduction to DSO | TB1, OER2 | Peer Presentations |

| | | | |
|---|---|---|---|
| 11 | Specifications of CRO | TB1, OER2 | Lectures, Discussions |
| 12 | Principles of Voltage Measurement | TB1, OER2 | Demonstrations, Labs |
| 13 | Digital Storage Oscilloscope | TB1, OER2 | Lectures, Discussions |
| 14 | Digital Storage Oscilloscope working | TB1, OER2 | Case Studies |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Understand the basics of measurement instruments and their specifications. | - Lectures<br>- Presentations<br>- Problem-Solving Sessions | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Analyze the working principles of Analog and digital voltmeter, ammeter and multimeter. | - Lecture<br>- Discussions<br>- Problem-Solving Sessions | |
| III | Analyze the working principles of Cathode Ray Oscilloscope (CRO) and Digital Storage Oscilloscope (DSO).<br>And Apply CROs and DSOs for voltage measurement and time base operation. | - Lecture<br>- Problem-Solving Sessions<br>- Practical Exercises | |

| | | | | | |
|---|---|---|---|---|---|
| **UNS101** | Study of Materials | L | T | P | C |
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | -- | | | | |

**Course Objective:** All the modern modern materials show some unique properties which either are by the virtue of material or may be tailored. Metallurgists and Materials scientists are responsible for designing and producing new materials. The desired properties may be introduced in the materials by altering their microstructures. This course will help students understand the properties of different types of materials and their applications. The course will also helpful to develop new kind of materials for engineering applications.

**Course Outcomes:**

CO1: Understand the mechanical properties of metals, including stress-strain behavior, plastic deformation, and hardness.

CO2: Analyze dislocations and strengthening mechanisms in metals, including grain size reduction and

strain hardening.
CO3: Describe the solid solutions and phase diagrams, including unary & binary phase diagrams and eutectic systems.
CO4: Examine the failures of metals, including fracture, fatigue, creep, and corrosion mechanisms and prevention.

UNIT I
Mechanical Properties of Metals 13 Lectures
Concepts of Stress and Strain, Elastic Deformation: Stress-Strain Behavior, Anelasticity, Elastic Properties of Materials; Plastic Deformation: Tensile Properties, True Stress and Strain, Elastic Recovery after Plastic Deformation, Compressive, Shear, and Torsional Deformation, Hardness; Property Variability And Design/Safety Factors: Variability of Material Properties, Design/Safety Factors.
UNIT II
Dislocations and Strengthening Mechanisms 14 Lectures
Characteristics of Dislocations, Slip Systems, Slip in Single Crystals, Plastic Deformation of Polycrystalline Materials, mechanism of plastic deformation, deformation by twinning,
Mechanisms Of Strengthening In Metals: Strengthening by Grain Size Reduction, 7.9 Solid-Solution Strengthening, Strain Hardening; Recovery, Recrystallization and Grain Growth: Recovery, Recrystallization, Grain Growth.

UNIT III 13 Lectures
Solid solutions and phase diagram
Introduction to single and multiphase solid solutions and types of solid solutions, importance and objectives of phase diagram, systems, phase and structural constituents, cooling curves, unary & binary phase diagrams, Gibbs's phase rule, Lever rule, eutectic and eutectoid systems, peritectic and peritectoid systems, iron carbon equilibrium diagram and TTT diagram.

UNIT IV 14 Lectures
Failures of metals
Failure analysis, fracture, process of fracture, types of fracture, fatigue, characteristics of fatigue, fatigue limit, mechanism of fatigue, factors affecting fatigue.
Definition and concept of Creep, creep curve, mechanism of creep, impact of time and temperature on creep, creep fracture, creep testing and prevention against creep.

Corrosion: Mechanism and effect of corrosion, prevention of corrosion
TEXT BOOKS:
1. Materials Science and Engineering:An Introduction (7th Ed.), William D. Callister, Jr., John Wiley & Sons, Inc.
2. Elements of Material Science and Engineering: VanVlack, Wesley Pub. Comp.
3. Material Science - Narula, Narula and Gupta. New Age Publishers
REFERENCE BOOKS:
1. Material Science & Engineering –V. Raghvan, Prentice Hall of India Pvt. Ltd, New Delhi.
2. A Text Book of Material Science & Metallurgy – O.P. Khanna, Dhanpat Rai & Sons
3. Engineering Materials: Kenneth G. Budinski, Prentice Hall of India, New Delhi

**Open Educational Resources (OER)**

**https://www.govinfo.gov/content/pkg/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c/pdf/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c.pdf**

https://uomustansiriyah.edu.iq/media/lectures/6/6_2018_05_19!12_50_38_AM.pdf

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS101 Study of Materials | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CO2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CO3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CO4 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

**Course Content: Mechanical Properties of Metals (Unit I)**

| Indicator | Relevant Course Content |
|---|---|
| Local | Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties |
| Regional | - |
| National | Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties |
| Global | Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties |
| Employability | Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties |
| Entrepreneurship | - |
| Skill Development | Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness |

| | |
|---|---|
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

**Course Content: Dislocations and Strengthening Mechanisms (Unit II)**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth |
| Regional | - |
| National | Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth |
| Global | Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth |
| Employability | Characteristics of Dislocations, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth |
| Entrepreneurship | - |
| Skill Development | Characteristics of Dislocations, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth |
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

**Course Content: Solid Solutions and Phase Diagrams (Unit III)**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | - |
| Regional | - |
| National | Introduction to solid solutions, Phase Diagrams, Gibbs's phase rule, Lever rule, Iron-Carbon Equilibrium Diagram |
| Global | Introduction to solid solutions, Phase Diagrams, Gibbs's phase rule, Lever rule, Iron-Carbon Equilibrium Diagram |
| Employability | - |
| Entrepreneurship | - |
| Skill Development | - |
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |

| | |
|---|---|
| Nep 2020 | - |
| Poe/4th IR | - |

**Course Content: Failures of Metals (Unit IV)**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep |
| Regional | - |
| National | Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep |
| Global | Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep |
| Employability | Failure analysis, Fatigue, Creep, Prevention against Creep |
| Entrepreneurship | - |
| Skill Development | Failure analysis, Fatigue, Creep |
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

# Teaching Plan:

| **Week** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ OER** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Concepts of Stress and Strain, Elastic Deformation | TB1, OER1 | Lecture, Conceptual Explanation |
| 2 | Plastic Deformation, Tensile Properties, True Stress and Strain | TB1, OER1 | Lecture, Examples, Problem Solving |
| 3 | Compressive, Shear, and Torsional Deformation, Hardness | TB1, OER1 | Lecture, Practical Examples, Lab Work |
| 4 | Property Variability and Design/Safety Factors | TB1, OER2 | Lecture, Case Studies |
| 5 | Characteristics of Dislocations, Slip Systems | TB1, OER2 | Lecture, Case Studies, Discussions |
| 6 | Slip in Single Crystals, Plastic Deformation of Polycrystalline Materials | TB1, OER2 | Lecture, Examples, Graphical Representation |
| 7 | Mechanisms of Strengthening in Metals: Grain Size Reduction, Solid-Solution Strengthening | TB1, OER2 | Lecture, Conceptual Exercises, Discussions |
| 8 | Strain Hardening; Recovery, Recrystallization, and Grain Growth | TB1, OER2 | Lecture, Practical Examples, Lab Work |
| 9 | Introduction to Solid Solutions and Phase Diagrams | TB1, OER2 | Lecture, Examples, Problem Solving |

| | | | |
|---|---|---|---|
| 10 | Unary and Binary Phase Diagrams, Gibbs's Phase Rule | TB1, OER2 | Lecture, Case Studies, Problem-Solving Sessions |
| 11 | Lever Rule, Eutectic and Eutectoid Systems | TB1, OER2 | Lecture, Case Studies, Group Discussions |
| 12 | Peritectic and Peritectoid Systems, Iron-Carbon Equilibrium Diagram | TB1, OER2 | Lecture, Examples, Graphical Representation |
| 13 | TTT (Time-Temperature-Transformation) Diagram, Failure Analysis | TB1, OER2 | Lecture, Case Studies, Discussions |
| 14 | Creep and Fatigue Mechanisms, Prevention Against Creep | TB1, OER2 | Lecture, Practical Examples, Lab Work |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Understand the concepts of stress and strain and their relevance to mechanical properties of metals | - Lectures<br>- Presentations<br>- Problem-Solving Sessions | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Describe dislocations and their role in plastic deformation of materials. | - Lecture<br>- Discussions<br>- Problem-Solving Sessions | |
| III | Introduce the concept of solid solutions and phase diagrams in materials | - Lecture<br>- Problem-Solving Sessions<br>- Practical Exercises | |
| IV | Analyze the failures of metals, including fracture, fatigue, and creep mechanisms | Group presentations on preventive measures and case studies.<br>- Lecture<br>- Problem-Solving Sessions | |

## Semester II

| S.No | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH102 | Mathematical Physics II | 4 |
| 2 | SCPH104 | Mechanics | 4 |
| 3 | SCPH152 | Mechanics Lab | 1 |

| | | | |
|---|---|---|---|
| 4 | AEC002 | Communicative English-II | 3 |
| 5 | | Value Added Course (Based on Extension Activity) | 2 |
| 6 | | Open Elective/Generic Elective-I | 3 |
| 7 | SEC016 | Physics Workshop Skill | 2 |
| 8 | UNS102 | Elements of Nanosciences and nanomaterials | 4 |
| | SIPH001 | Summer Internship /Project | |
| | | TOTAL | 23 |

| SCPH102 | Mathematical Physics-II | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Calculus | | | | |
| **Co-requisites** | Mathematical Physics-I | | | | |

**Course Objectives**

1. To make them learn about the Fourier series expansion and its applications.
2. To enable them to use theory of errors on various types of data.
3. To give knowledge of special Functions such as Legendre, Bessel, Hermite and Laguerre and their properties.
4. To impart knowledge about various mathematical tools employed to study physics problems.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Understand Fourier series and its application for periodic and non-periodic functions.
CO2: Apply Frobenius method to solve second-order differential equations and special functions.
CO3: Comprehend Beta, Gamma functions, and Error Function for evaluating integrals and handling errors.
CO4: Solve partial differential equations using separation of variables for wave and diffusion equations.

**Catalog Description**

This course aims to demonstrate the use of mathematical techniques in solving problems in Physics and to provide a deeper understanding of the mathematics underpinning theoretical physics. The course is intended to develop the theory of errors, Fourier series, special functions and partial differential equations. Emphasis will be on illustrative examples from Physics and Engineering.

**Course Content**

**UNIT-I** **14 Lecture Hours**

**Fourier Series:** Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

**UNIT-II** **14 Lecture Hours**

**Frobenius Method and Special Functions:** Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality.

**UNIT-III** **13 Lecture Hours**

**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

**Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope andintercept of a fitted line.

**UNIT-IV** **13 Lecture Hours**

**Partial Differential Equations:** Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

**Text Books:**

TB1:Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.

TB2:Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

**Reference Books:**

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Open Educational Resources (OER)

OER1: https://math.mit.edu/~gs/cse/websections/cse41.pdf

OER2:

https://www.researchgate.net/publication/250156802_Notes_on_Special_Functions

OER3: https://ocw.mit.edu/courses/18-152-introduction-to-partial-differential-equations-fall-2011/resources/mit18_152f11_lec_01/

## Assessment & Evaluation

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

### Programme And Course Mapping

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH102 Mathematical Physics-II | CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 2 |
| | CO2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 3 | 2 | 3 |
| | CO3 | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | 3 | 1 |
| | CO4 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Fourier series |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Mathematical techniques like Fourier series expansion |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Frobenius method and special functions |
| Local | - |
| Regional | - |
| National | - |
| Global | Analytical reasoning,<br>- |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Some special integrals, theory of errors |
| Local | - |
| Regional | - |
| National | - |
| Global | Critical thinking |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Partial differential equations |
| Local | - |
| Regional | - |
| National | - |
| Global | Scientific reasoning |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & | - |

| | |
|---|---|
| sustainability | |
| SDG | Quality education (4) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |

## Teaching Plan

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Orthogonality of sine and cosine functions | TB1, OER1 | Lectures, Discussions |
| 2 | Expansion of periodic functions | TB1, OER1 | Online Tutorials, Quizzes |
| 3 | Complex representation of Fourier series | TB1, OER1 | Problem-Solving Sessions |
| 4 | Expansion of functions with arbitrary period | TB1, OER2 | Group Projects |
| 5 | Expansion of non-periodic functions | TB1, OER2 | Demonstrations, Labs |
| 6 | Even and odd functions and their Fourier exp | TB1, OER2 | Guest Lectures |
| 7 | Application of Fourier series | TB1, OER3 | Practical Exercises |
| 8 | Summing of Infinite Series | TB1, OER3 | |
| 9 | Term-by-Term differentiation and integration | TB1, OER3 | Virtual Simulations |
| 10 | Parseval Identity | TB1, OER3 | Peer Presentations |
| 11 | Frobenius Method and Special Functions | TB1, OER3 | Problem-Based Learning |
| 12 | Singular Points of Second Order Linear Diff. | TB1, OER3 | Case Studies |
| 13 | Legendre, Bessel, Hermite and Laguerre Diff. | TB1, OER3 | Interactive Workshops |
| 14 | Orthogonality of sine and cosine functions | TB1, OER3 | Revision Lectures |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Understand Fourier Series and their applications. | - Lectures<br>- Presentations<br>- Discussions | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations. |
| II | Apply Frobenius method to solve special differential equations. | - Problem-Solving Sessions<br>- Discussions<br>- Case Studies | |
| III | Comprehend Beta, Gamma functions, and their applications. | - Lecture<br>- Guest Lectures | |

| | | | |
|---|---|---|---|
| | | - Practical Exercises | ➢ End-term examinations |
| IV | Solve partial differential equations using separation of variables. | - Guest Lectures | |
| | | - Demonstrations | |
| | | - Problem-Solving Sessions | |
| | | | |

| SCPH104 | MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basic Physics and Mathematics | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To acquire the knowledge of fundamentals of motion of objects, work, energy and collisions

2. To understand the concepts of rotational dynamics, elasticity and fluid motion.

3. To gain insight to the theory of gravitation and oscillations.

4. To have an insight about non-inertial systems and Special Theory of Relativity.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Understand fundamentals of dynamics, conservation laws, impulse, and energy principles in mechanics.
CO2: Analyze rotational dynamics, moment of inertia, and motion under central forces.
CO3: Comprehend oscillations, damping, resonance, non-inertial frames, and relativistic effects.
CO4: Apply principles to collisions, fluid motion, elasticity, and relativistic kinematics..

**Catalog Description**

This course is intended to introduce the basic concepts of physics related to motion of objects. It discusses the logic behind many events that we observe around us in day to day life. It emphasizes on the relationship between force, matter and motion under different circumstances. This course is a bridge between the basic and advance concepts of physics.

**Course Content**

**UNIT-I** **14 Lecture Hours**

**Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by nonconservative forces. Law of conservation of Energy.

**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

**UNIT-II** **14 Lecture Hours**

**Rotational Dynamics:** Angular momentum of a particle and system of particles.Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

**Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.
**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.
**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.
Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

**UNIT-III** **13 Lecture Hours**

**Oscillations:** SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.
**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

**UNIT-IV** **13 Lecture Hours**

**Special Theory of Relativity:** Michelson-Morley Experiment and its outcome.Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

**Text books:**

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

**Reference book(s) [RB]:**

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Open Educational Resources (OER)

OER1:
https://www.fisica.net/mecanicaclassica/introduction_to_statics_and_dynamics_by_rudra_pratap.pdfhttps://www.fisica.net/mecanicaclassica/introduction_to_statics_and_dynamics_by_rudra_pratap.pdf

OER2: https://www.youtube.com/watch?v=W8_Vr7zzA84

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH104 Mechanics | CO1 | 3 | | | | | | | | | | | | | |
| | CO2 | | 3 | | | | | | | | | | | | |
| | CO3 | | | 3 | | | | | | | | | | | |
| | CO4 | | | | 3 | | | | | | | | | | |

1=lightly mapped 2= moderately mapped 3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| | |
|---|---|
| Unit i | Fundamentals of dynamics, work and energy, collisions |
| Local | - |
| Regional | - |
| National | - |
| Global | Basic concepts of physics related to motion of objects. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Rotational dynamics, elasticity, fluid motion, gravitation and central force motion |
| Local | - |
| Regional | - |
| National | - |
| Global | Basic concepts of physics related to motion of objects. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | oscillations, non-inertial systems |
| Local | - |
| Regional | - |
| National | - |

| | |
|---|---|
| Global | Discussion of the logic behind many events that we observe around us in day to day life. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Special theory of relativity |
| Local | - |
| Regional | - |
| National | - |
| Global | Discussion of the logic behind many events that we observe around us in day to day life. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Projects and group discussion |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Fundamentals of Dynamics | TB1, OER1 | Lecture, Conceptual Explanation |
| 2 | Galilean transformations; Newton's Laws | TB1, OER1 | Lecture, Examples, Problem Solving |
| 3 | Momentum of variable-mass system | TB1, OER1 | Lecture, Practical Examples, Lab Work |
| 4 | Motion of a projectile | TB1, OER1 | Lecture, Demonstrations |
| 5 | Dynamics of a system of particles | TB1, OER1 | Lecture, Case Studies |
| 6 | Principle of conservation of momentum | TB1, OER1 | Lecture, Group Discussions |
| 7 | Work and Kinetic Energy Theorem | TB1, OER1 | Lecture, Practical Examples, Case Studies |
| | Conservative and non-conservative forces | TB1, OER1 | Lecture, Group Discussions |
| 9 | Potential Energy | TB1, OER1 | Lecture, Group Discussions |

| | | | |
|---|---|---|---|
| 10 | Elastic potential energy | TB1, OER1 | Lecture, Practical Examples, Lab Work |
| 11 | Collisions: Elastic and inelastic collisions | TB1, OER1 | Lecture, Conceptual Explanation |
| 12 | Rotation about a fixed axis | TB1, OER2 | Lecture, Demonstrations |
| 13 | Moment of Inertia | TB1, OER2 | Lecture, Practical Examples, Lab Work |
| 14 | Motion involving both translation and rotation | TB1, OER2 | Lecture, Case Studies |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Understand fundamentals of dynamics, conservation laws, impulse, and energy principles in mechanics. | - Lectures<br>- Presentations<br>- Discussions | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Analyze motion involving both translation and rotation. | - Problem-Solving Sessions<br>- Discussions<br>- Case Studies | |
| III | Comprehend special theory of relativity and its applications. | - Lecture<br>- Guest Lectures<br>- Practical Exercises | |
| IV | Analyze postulates and Lorentz Transformations of Special Theory of Relativity, Time Dilation, and Length Contraction. | - Guest Lectures<br>- Demonstrations<br>- Problem-Solving Sessions | |

| SCPH152 | MECHANICS LAB | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 27 | | | | |
| **Pre-requisites/Exposure** | Mechanics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

5. Demonstration cum laboratory sessions on the concepts of mechanics such as moment of inertia, determination of ‘g’ and elastic constants of materials.
6. Sessions on the review of scientific laboratory report writing, and on experimental data analysis.
7. Expand and exercise the students’ physical intuition and thinking process through the

experiments.

8. Interpretation of experimental data.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Demonstrate proficiency in using basic instruments for measurements in the laboratory.
CO2: Analyze and quantify random errors in experimental observations.
CO3: Apply experimental techniques to determine physical properties like spring constant and modulus of rigidity.
CO4: Utilize appropriate methods to determine gravitational acceleration (g) and other mechanical constants.

**Catalog Description**

This course involves the experimental verification of concepts of mechanics. The course is design to give knowledge how to use basic instruments in laboratory and laboratory experiment protocols. The main focus is on data collection techniques and the data interpretation. For this purpose a series of experiments have been set. The difficulty level of experiments is set easy to moderate level due to introductory physics.

**Course Content**

At least 08 experiments from the following:

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

**References for Laboratory Work:**


1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
4. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt.Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.


Open Educational Resources (OER)

OER1: phet.colorado.edu

## Assessment & Evaluation

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

## Programme And Course Mapping

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH152 Mechanics Lab | CO1 | 3 | 1 | | | | | | | | | 3 | 1 | | |
| | CO2 | | 3 | 2 | | | | | | | | | 2 | | |
| | CO3 | | | 3 | | 2 | 1 | | | | | | | 3 | 1 |
| | CO4 | | | | 3 | | | 2 | 3 | 1 | | | | | |

1=lightly mapped 2= moderately mapped 3=strongly mapped

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Mechanics lab |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Experimental verification of concepts of mechanics |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Mechanics |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4th IR | Hands-on experience,<br>Projects |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Experiment 1<br>Measurements using vernier caliper, screw gauge, and travelling microscope | OER1 | Introduction to laboratory equipment and safety measures.<br>Demonstration and hands-on practice with measurement instruments.<br>Discussion on measurement techniques. |
| 2 | Experiment 2<br>Study of random errors in observations | OER1 | - Lecture on sources of errors and error analysis.<br>Experiment setup for random error determination.<br>Data collection and error calculations. |
| 3 | Experiment 3<br>Determination of building height using a Sextant | OER1 | - Introduction to Sextant and its working principle.<br>Practical demonstration of Sextant usage.<br>Calculation of building height. |
| 4 | Experiment 4<br>Study of Motion of Spring and calculation of Spring constant, 'g', and Modulus of rigidity | OER1 | - Introduction to spring motion and related concepts.<br>Experiment setup for motion of spring and data collection.<br>Calculation of spring constant, 'g', and modulus of rigidity. |
| 5 | Experiment 5<br>Determination of Moment of Inertia of a Flywheel | OER1 | Discussion on moment of inertia and its importance.<br>Practical demonstration of flywheel experiment.<br>Data analysis and calculation of moment of inertia. |
| 6 | Experiment 6<br>Determination of 'g' and velocity using Digital Timing Technique | OER1 | - Introduction to free fall motion and timing techniques.<br>Experiment setup and data collection using digital timing.<br>Calculation of 'g' and velocity. |
| 7 | Experiment 7 | OER1 | - Explanation of |

| | | | |
|---|---|---|---|
| | Determination of Coefficient of Viscosity by Capillary Flow Method | | viscosity and capillary flow method.<br>Practical demonstration of viscosity experiment.<br>Data analysis and calculation of viscosity coefficient. |
| 8 | Experiment 8<br>Determination of Young's Modulus using Optical Lever Method | OER1 | - Introduction to Young's Modulus and optical lever method.<br>Practical setup and measurement of Young's Modulus. Data analysis and calculations. |
| 9 | Experiment 9<br>Determination of Modulus of Rigidity using Maxwell's Needle | OER1 | - Concept of rigidity modulus and Maxwell's needle method.<br>Experimental setup and measurements.<br>Calculation of rigidity modulus. |
| 10 | Experiment 10<br>Determination of elastic Constants of a wire by Searle's method | OER1 | - Discussion on elasticity and Searle's method.<br>Practical setup and measurements.<br>Calculation of elastic constants. |
| 11 | Experiment 11<br>Determination of 'g' using Bar Pendulum | OER1 | - Explanation of bar pendulum and its usage.<br>Practical setup and measurements.<br>Calculation of gravitational acceleration 'g'. |
| 12 | Experiment 12<br>Determination of 'g' using Kater's Pendulum | OER1 | - Introduction to Kater's pendulum and working principle.<br>Practical setup and measurements.<br>Calculation of gravitational acceleration 'g'. |
| 13 | Review and Preparation<br>Recap and review of experiments | OER1 | Comprehensive review of all experiments and concepts. Clarification of doubts and discussion. |
| 14 | Review and Preparation<br>Recap and review of experiments | OER1 | Comprehensive review of all experiments and concepts. Clarification of doubts and discussion. |

| | | | | | |
|---|---|---|---|---|---|
| AEC002 | New Age Life Skills-II | L | T | P | C |
| **Version 1.0** | | 3 | | 0 | 3 |
| **Total Contact Hours** | 39 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | -- | | | | |

| SEC016 | Physics Workshop Skill | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 2 | | 0 | 2 |
| **Total Contact Hours** | 27 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

9. To make them learn about the different measuring instruments.
10. To enable them to use mechanical skill for development of new tools.
11. To give knowledge of soldering process.
12. To impart knowledge about gear systems, lever and pulley.

**Course Outcomes**

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

CO1: Measure and convert physical quantities using appropriate instruments and units.
CO2: Demonstrate knowledge of workshop practices and various manufacturing methods.
CO3: Apply electrical and electronic skills to construct and troubleshoot circuits using discrete components and ICs.

**Catalog Description**

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode. To make them learn about the different measuring instruments. To enable them to use mechanical skill for development of new tools. To give knowledge of soldering process. To impart knowledge about gear systems, lever and pulley.

**Course Content**

**UNIT-I** **7 Lecture Hours**

**Introduction:** Measuring units. conversion to SI and CGS. Familiarization with meterscale,Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc.

**UNIT-II** **10 Lecture Hours**

**Mechanical Skill:** Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils.

**UNIT-III** **10 Lecture Hours**

**Electrical and Electronic Skill:** Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power

supply. Timer circuit, Electronic switch using transistor and relay.

**Text Books:**

TB1: A text book in Electrical Technology - B L Theraja – S. Chand and Company.

TB2: Performance and design of AC machines – M.G. Say, ELBS Edn.

TB3: Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd

**Reference Books:**

RB1: Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]

RB2: New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

**Open Educational Resources (OER)**

OER1 **https://www.youtube.com/watch?v=i9ixyz8y2gA**

OER2 **https://www.youtube.com/watch?v=ynnJVpdhX3o**

OER3 **https://www.youtube.com/watch?v=mc979OhitAg&list=PLWv9VM947MKi_7yJ0_FCfzTBXpQU-Qd3K**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEC016/ Physics Workshop Skill | CO1 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | - | - | - |
| | **CO2** | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | - | - | - |
| | **CO3** | - | - | - | - | - | - | - | - | - | - | 1 | 3 | 3 | 3 |

1=lightly mapped 2= moderately mapped 3=strongly mapped

## Teaching Plan

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | UNIT-I: Introduction to Measuring Units | TB 1/RB2 | Lecture |
| | Conversion to SI and CGS | TB 1 | |
| | Familiarization with meterscale, Vernier caliper, Screw gauge, and their utility | **OER1** | |
| 2 | UNIT-I (Contd.): Measurement of Dimension of a Solid Block | TB-2 | Practical/Lab |
| | Measurement of Volume of Cylindrical Beaker/Glass | TB 1 | |
| 3 | UNIT-I (Contd.): Measurement of Diameter of a Thin Wire | TB 1 | Practical/Lab |
| | Measurement of Thickness of Metal Sheet | TB 1 | |
| 4-5 | UNIT-II: Concept of Workshop Practice | TB 3 | Lecture |
| | Overview of Manufacturing Methods: Casting, Foundry, Machining, Forming, and Welding | **OER2** | |
| 6 | UNIT-II (Contd.): Types of Welding Joints and Welding Defects | TB 3 | Lecture |
| 7-8 | UNIT-II (Contd.): Common Materials Used for Manufacturing | TB 3 | Lecture |
| | Concept of Machine Processing | TB 3 | |
| 9-10 | UNIT-II (Contd.): Introduction to Common Machine Tools | TB 3 | Practical/Lab |
| | (Lathe, Shaper, Drilling, Milling, and Surface Machines) | TB 3 | |
| 11 | UNIT-II (Contd.): Cutting Tools and Lubricating Oils | TB 3 | Practical/Lab |
| 12 | UNIT-III: Use of Multimeter | TB-1 | Practical/Lab |
| 13 | UNIT-III (Contd.): Soldering of Electrical Circuits with Discrete Components (R, L, C, Diode) on PCB | OER3 | Practical/Lab |
| 14 | UNIT-III (Contd.): Operation of Oscilloscope, Making Regulated Power Supply | TB-1 | Practical/Lab |
| | Timer Circuit and Electronic Switch Using Transistor and Relay | TB-1 | |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CLOs) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| UNIT-I | Apply appropriate measuring units and conversions. | Lectures, discussions, and examples. | ➢ Presentations and class discussions. |
| | Utilize meterscale, Vernier caliper, and Screw gauge. | Laboratory demonstrations and hands-on practice. | |
| | Measure dimensions of solid blocks and cylindrical beakers accurately. | Group activities to measure various objects. | |

| | | | |
|---|---|---|---|
| | Demonstrate an understanding of standard units and accurate measuring. | Problem-solving sessions and real-world applications. | ➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| UNIT-II | Explain the principles of workshop practices. | Lectures on workshop techniques and safety precautions. | |
| | Compare and contrast various manufacturing methods. | Case studies on different manufacturing processes. | |
| | Identify different types of welding joints and defects. | Welding demonstrations and practical exercises. | |
| | CLO8: Analyze properties and applications of materials used in manufacturing. | Discussions on material properties and hands-on material testing. | |
| UNIT-III | Operate a multimeter proficiently to measure electrical quantities. | Hands-on training with multimeters and circuits. | |
| | Demonstrate skill in soldering electrical circuits. | PCB soldering exercises and soldering workshops. | |
| | Utilize an oscilloscope effectively for circuit analysis. | Oscilloscope labs and signal visualization exercises. | |
| | Design and construct a regulated power supply. | Design projects with hands-on power supply construction. | |
| | Create timer circuits and electronic switches using transistors. | Circuit design and implementation activities. | |
| | | | |

| UNS102 | Elements of Nano sciences and nanomaterial | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of Chemistry | | | | |
| **Co-requisites** | -- | | | | |

**Course Description**

The aim of this course is to introduce an emerging class of materials called nanomaterials that consists of a broad spectrum of examples with at least one dimension in the range of 1 to 100 nm. Exceptionally high surface areas can be achieved through the rational design of nanomaterials. It will also explain how nanomaterials can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties that are substantially different from their bulk counterparts. The course will conclude with various types of characterization techniques which can be used for analysing these nanomaterials.

**Course Outcomes**

**CO1:** Learning about the background of nanoscience and understanding how it has been existent in nature since ages.
**CO2:** Knowledge about quantum mechanics and applying it understanding nano effects.
**CO3:** Analysing various ways of synthesising nanomaterial.
**CO4:** Evaluating ways for the structure and properties of nanomaterials.

**Unit I** **12 Lectures**

**Background to Nano science:** Definition of Nano, Scientific revolution-atomic Structure and atomic size, emergence and challenges of nano science and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of Nano over micro/macro, size effects and crystals, large surface to volume ratio, surface effects on the properties. Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties.

**Unit-II** **13 Lectures**

**Introduction to Quantum Mechanics:** Schrodinger equation and expectation values, Solutions of the Schrodinger equation for free particle, particle in a box, particle in a finite well, Reflection and transmission by a potential step and by a rectangular barrier. Angular momentum and its operators, Eigen values and Eigen functions of the angular momentum operators, spin, Pauli spin operators and their properties, hydrogen atom, density of states, free electron theory of metals.

**Unit III** **15 Lectures**

**Types of nanostructure and properties of nanomaterial:** One dimensional, two dimensional and three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

**Chemical synthesis of nano material**: Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, colloids, zeolites, organic block copolymers, emulsion polymerization, template synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-template nucleation and/or crystallization. Vapour (or solution) – liquid – solid (VLS or SLS) growth -Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition

**Unit IV** **14 Lectures**

**Characterization of nanomaterial:** X-ray Diffraction - Thermal Analysis Methods, Differential Thermal Analysis and Differential scanning calorimetry - Spectroscopic techniques, UV-Visible Spectroscopy – IR Spectroscopy – Microwave Spectroscopy - Raman **Spectroscopy:** Electron Spin Resonance Spectroscopy, NMR Spectroscopy, **Particle size characterization:** Zeta Potential Measurement, **Particle size Analysis:** X-ray Photoelectron spectroscopy. **Imaging techniques for nanotechnology**: Scanning Electron Microscopy, Transmission Electron Microscopy, and Atomic

Force Microscopy.

**Textbooks**

TB1 : Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.

TB2: Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.

TB3: Nanoscale materials in chemistry by Kenneth J. Klabunde, Wiley Interscience Publications, 2001.

TB4: Nanochemistry by Sergeev G.B., Elseiver publication, 2006.

TB5: Quantum Physics – A. Ghatak

**Reference Books**

RB1: Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.

RB2: Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.

RB3: Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.

RB4: Processing & properties of structural naonmaterials - Leon L. Shaw, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

**Open Educational Resources (OER)**

**https://www.youtube.com/watch?v=0EWCqCIsFOA**

**https://www.youtube.com/watch?v=-K7Gs0Nj-5o&list=PLQzUXa8lZVq__y0i5dOjW6oEr6h43bJCV**

**https://nptel.ac.in/courses/118104008**

**https://nptel.ac.in/courses/115101007**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS102/ Elements of Nano sciences and nanomaterial | CO1 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| | **CO2** | 3 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| | **CO3** | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 2 | 3 |
| | **CO4** | 3 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | **Background to Nano science** |
|---|---|
| Local | Understanding the impact of nanoscience on local industries and research. |
| Regional | - |
| National | Advancing national capabilities in nanotechnology research and quantum mechanics understanding. |
| Global | Contributing to global scientific advancements and collaborations in nanoscience. |
| Employability | Equipping students with knowledge of emerging nanotechnology trends. |
| Entrepreneurship | Facilitating innovation in nanotechnology-related startups. |
| Skill development | Developing analytical and research skills in nanoscience. |
| Professional ethics | Encouraging ethical conduct in nanotechnology research. |
| Gender | - |
| Human values | - |
| Environment & sustainability | Exploring sustainable nanomaterials and their applications. |
| Unit ii | **Introduction to Quantum Mechanics** |
| Local | Enabling local industries to adopt quantum mechanics principles in materials research. |
| Regional | - |
| National | Strengthening the understanding of quantum mechanics in national research. |
| Global | Enhancing global knowledge in quantum mechanics for advanced technologies. |
| Employability | Equipping students with quantum mechanics skills for diverse careers. |
| Entrepreneurship | Fostering innovation in quantum technology startups. |
| Skill development | Developing problem-solving skills in quantum mechanics. |
| Professional ethics | Promoting ethical research in quantum mechanics. |
| Gender | - |
| Human values | - |
| Environment & sustainability | Exploring quantum solutions for environmental challenges. |
| Unit iii | **Types of nanostructure and properties of nanomaterial** |
| Local | Promoting the local production of nanomaterials with specific properties. |
| Regional | - |
| National | Advancing national nanomaterial research and development. |

| | |
|---|---|
| Global | Contributing to global advancements in nanomaterial science. |
| Employability | Enhancing students' employability in nanotechnology-related fields. |
| Entrepreneurship | Encouraging innovation in nanomaterial startups. |
| Skill development | Developing synthesis and characterization skills in nanomaterials. |
| Professional ethics | Emphasizing ethical considerations in nanomaterial research. |
| Gender | - |
| Human values | - |
| Environment & sustainability | Investigating sustainable nanomaterials and processes. |
| Unit iv | **Characterization of nanomaterial** |
| Local | Offering local industries access to nanomaterial characterization techniques. |
| Regional | - |
| National | Strengthening national capabilities in nanomaterial characterization. |
| Global | Contributing to global knowledge in nanomaterial characterization. |
| Employability | Enhancing students' employability in materials analysis fields. |
| Entrepreneurship | Facilitating innovation in nanomaterial characterization services. |
| Skill development | Developing expertise in advanced characterization techniques. |
| Professional ethics | Promoting ethical conduct in nanomaterial characterization. |
| Gender | - |
| Human values | - |
| Environment & sustainability | Ensuring environmentally responsible nanomaterial analysis. |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4$^{th}$ IR | Preparing students for the Fourth Industrial Revolution. |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER | Teaching-Learning Method |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Background to Nano Science | TB 1 | Lecture, Presentation |
| 2 | Introduction to Quantum Mechanics | TB 1 | Lecture, Problem Solving |
| 3 | Types of Nanostructure and Properties of Nanomaterials | TB 1 | Lecture, Case Studies |
| 4 | Chemical Synthesis of Nanomaterials | TB 2 | Lab Demonstrations, Hands-on Activities |
| 5 | X-ray Diffraction and Thermal Analysis Methods | TB 2 | Lecture, Lab Work |
| 6 | Spectroscopic Techniques for Nanomaterial Characterization | TB 3 | Lecture, Guest Lectures |
| 7 | Imaging Techniques for Nanotechnology | TB 3 | Lab Work, Demonstrations |
| 8 | Schrodinger Equation and Expectation Values | **https://nptel.ac.in/courses/118104008** | Lecture, Problem Solving |
| 9 | Reflection and Transmission by Potential Barriers | RB 1 | Lecture, Case Studies |
| 10 | One-Dimensional Nanostructured Materials | **https://nptel.ac.in/courses/115101007** | Lecture, Presentation |
| 11 | Spin and Pauli Spin Operators | RB 1 | Lecture, Problem Solving |
| 12 | Two-Dimensional and Three-Dimensional Nanostructured Materials | RB 1 | Lecture, Guest Lectures |
| 13 | Metal Oxides, Semiconductors, and Composites | **https://nptel.ac.in/courses/115101007** | Independent Study, Discussions |
| 14 | Nanomaterial Structure and Properties Evaluation | RB 3 | Independent Study, Discussions |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CO) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Learn about the background of nanoscience and understand its existence in nature since ages and Apply knowledge of quantum mechanics to understand nano effects. | - Lectures<br>- Presentations<br>- Discussions | ➢ Presentations and class discussions.<br>➢ Assignments and class tests.<br>➢ Student presentations.<br>➢ Mid-term examinations.<br>➢ End-term examinations |
| II | Apply knowledge of quantum mechanics to understand nano effects and Analyze various ways of synthesizing nanomaterials. | - Lab Demonstrations<br>- Hands-on Activities<br>- Case Studies | |
| III | CO3: Analyze various ways of synthesizing nanomaterials and Evaluate ways for the structure and properties of nanomaterials. | - Lecture<br>- Guest Lectures<br>- Independent Study | |
| IV | Evaluate ways for the structure and properties of nanomaterials. | - Lab Work<br>- Demonstrations<br>- Discussions | |

## III Semester

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH201 | Mathematical Physics III | 4 |

| | | | |
|---|---|---|---|
| 2 | SCPH203 | Solid State Physics | 4 |
| 3 | SCPH251 | Solid State Physics Lab | 1 |
| 4 | SCPH205 | Introduction of Nanochemistry and Applications | 4 |
| | SCPH207 | Green Processes Of Chemistry | |
| 5 | UNS103 | Nanostructured materials | 4 |
| 6 | AEC003 | New Age Life Skills-III | 3 |
| 7 | | Select one course from a basket of course | 3 |
| 8 | SIPH001 | Evaluation of Summer Internship /Project | 2 |
| Total | | | 25 |

| **SCPH201** | Mathematical Physics-III | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 Hours | | | | |
| **Pre-requisites/Exposure** | Calculus | | | | |
| **Co-requisites** | Mathematical Physics-I, II | | | | |

**Course Objectives**

1. To make them learn about the complex numbers and their properties, functions of complex numbers and their properties such as analyticity, poles and residues.
2. To enable them to use residue theorem and its applications in evaluating definite Integrals.
3. To give knowledge of Fourier transform, Laplace Transform and their applications in real world problems.
4. To impart knowledge about various mathematical tools employed to study physics problems.

**Course Outcomes**

On completion of this course, the students will be able to

**CO1:** Identify and summarize the key concepts of Complex Analysis, including complex numbers, Euler's formula, De Moivre's theorem, and roots of complex numbers.

**CO2:** Apply the Cauchy-Riemann conditions to determine the analyticity of a complex function and identify singular functions, such as poles and branch points. Analyze the order of singularity and the concept of branch cuts.

**CO3:** Utilize Cauchy's Integral formula and residues to evaluate complex integrals in simply and multiply connected regions. Demonstrate proficiency in finding Laurent and Taylor expansions of complex functions.

**CO4:** Compare and contrast Fourier Transforms and their properties, including translation, change of scale, and complex conjugation. Apply Fourier Transforms to solve differential equations, particularly one-dimensional wave and diffusion/heat flow equations.

**Catalog Description**

This course aims to demonstrate the use of mathematical techniques in solving problems in Physics and to provide a deeper understanding of the mathematics underpinning theoretical physics. The course is intended to develop the theory of complex analysis and its applications, Fourier Transform and Laplace Transform, their properties and applications. Emphasis will be on illustrative examples from Physics and Engineering.

**Course Content**

**UNIT-I** **13 Lecture Hours**

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts.

**UNIT-II** **13 Lecture Hours**

Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Integrals Transforms: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral.

**UNIT-III** **14 Lecture Hours**

Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One

dimensional Wave and Diffusion/Heat Flow Equations.

**UNIT-IV** **14 Lecture Hours**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties ofLTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

**Text Books**

Mathematical Physics, H.K. Dass and R. Verma, S. Chand & Company.

**Reference Books/Materials**

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., 2006, Cambridge University Press.
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press.
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill.
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.

**Open Educational Resources (OER)**

- https://youtu.be/ysVcAYo7UPI
- https://youtu.be/QiwfF83NWNA
- https://www.coursera.org/lecture/complex-analysis/complex-functions-koxdh?utm_source=link&utm_medium=page_share&utm_content=vlp&utm_campaign=top_button
- https://youtu.be/OiNh2DswFt4
- https://youtu.be/33TYoybjqPg

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH201, Mathematical | CO1 | 3 | 3 | 3 | - | 3 | - | - | - | 1 | - | 3 | 2 | 3 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Physics-III** | **CO2** | 2 | 2 | 2 | - | 2 | 2 | - | - | - | 1 | 2 | 3 | 3 | 1 |
| | **CO3** | 2 | 2 | 2 | - | 2 | 2 | 2 | 2 | - | - | 1 | 3 | 3 | 2 |
| | **CO4** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | - | 3 | 3 | 1 | 3 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Complex analysis |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge about complex analysis and its importance |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Image processing using Fourier and Laplace transform |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Integrals |
| Local | - |
| Regional | - |
| National | - |
| Global | Introduction to Fourier transforms |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Image processing using Fourier and Laplace transform |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Fourier transform |
| Local | - |
| Regional | - |
| National | - |
| Global | Applications of Fourier transforms in diffusion and heat flow equations |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Image processing using Fourier and Laplace transform |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Laplace transforms |
| Local | - |
| Regional | - |
| National | - |

| | |
|---|---|
| Global | Laplace transform and its applications |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Image processing using Fourier and Laplace transform<br>- |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4th IR | Use of software and simulations<br>Projects and group discussion |

## Teaching Plan:

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|
| **Week 1** | Complex numbers and their graphical representation, Euler's formula, De Moivre's theorem, Roots of Complex Numbers, Analyticity and Cauchy-Riemann Conditions | Riley et al. (Ch. 1), Dennery & Krzywicki, Kapoor, Fokas & Ablowitz https://youtu.be/ysVcAYo7UPI | Lecture, Examples, Discussions |
| **Week 2** | Integration of a function of a complex variable, Cauchy's Inequality, Cauchy's Integral formula, Simply and multiply connected regions | Riley et al. (Ch. 4), (Ch 5), (Ch 6) https://youtu.be/QiwfF83NWNA | Lecture, Examples, Discussions |
| **Week 3** | Laurent and Taylor's expansion, Residues and Residue Theorem, Application in solving Definite Integrals | Riley et al. (Ch. 7), (Ch 8), (Ch 9) | Lecture, Examples, Discussions |
| **Week 4** | Fourier Integral theorem, Fourier Transform, Fourier transform of trigonometric, Gaussian, finite wave train & other functions | Riley et al. (Ch. 10, 11) | Lecture, Examples, Discussions |
| **Week 5** | Representation of Dirac delta function as a Fourier Integral | Riley et al. (Ch. 12) | Lecture, Examples, Discussions |
| **Week 6** | Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem, Properties of Fourier transforms | Riley et al. (Ch. 12) | Lecture, Examples, Discussions |
| **Week 7** | Three-dimensional Fourier transforms with examples, Application of Fourier Transforms to differential equations | Riley et al. (Ch. 13, 14) https://www.coursera.org/lecture/complex-analysis/complex-functions-koxdh?utm_source=link&utm_medium=page_share&utm_content=vlp&ut | Lecture, Examples, Discussions |

| | | | |
|---|---|---|---|
| | | m_campaign=top_button | |
| **Week 8** | Laplace Transform (LT) of Elementary functions, Properties of LTs: Change of Scale Theorem, Shifting Theorem | Riley et al. (Ch. 15) https://www.coursera.org/lecture/complex-analysis/complex-functions-koxdh?utm_source=link&utm_medium=page_share&utm_content=vlp&utm_campaign=top_button | Lecture, Examples, Discussions |
| **Week 9** | LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs | Riley et al. (Ch. 15) | Lecture, Examples, Discussions |
| **Week 10** | LT of Unit Step function, Dirac Delta function, Periodic Functions, Convolution Theorem, Inverse LT | Riley et al. (Ch. 15) https://youtu.be/OiNh2DswFt4 | Lecture, Examples, Discussions |
| **Week 11** | Application of Laplace Transforms to 2nd order Differential Equations | Riley et al. (Ch. 15) https://youtu.be/OiNh2DswFt4 | Lecture, Examples, Discussions |
| **Week 12** | Review of important concepts and techniques | Riley et al., Kapoor, Fokas & Ablowitz | Lecture, Examples, Discussions |
| **Week 13** | Review of important concepts and techniques | Riley et al., Kapoor, Fokas & Ablowitz | Lecture, Examples, Discussions |
| **Week 14** | Application of complex analysis and transforms in Physics | Riley et al., Kapoor, Fokas & Ablowitz | Lecture, Examples, Discussions |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | • Recall the properties of complex numbers and represent them graphically. Apply Euler's formula and De Moivre's theorem to manipulate complex numbers.<br>• Determine and calculate roots of complex numbers.<br>• Understand and define functions of complex variables.<br>• Verify the analyticity of complex functions using Cauchy-Riemann conditions | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | • Utilize Cauchy's Integral formula to evaluate complex integrals in simply and multiply connected regions.<br>• Find Laurent and Taylor expansions of complex functions and apply them in relevant contexts.<br>• Compute residues and apply the Residue Theorem to evaluate complex integrals.<br>• Apply complex analysis techniques to solve definite integrals.<br>• Understand the concept of Fourier Transforms and their properties, including translation, change of scale and complex conjugation.<br>• Calculate Fourier Transforms for various functions, including trigonometric, Gaussian, and finite wave train functions.<br>• Represent the Dirac delta function as a Fourier Integral. | | |
| **3** | • Apply the Convolution theorem and understand the properties of Fourier transforms. | | |

| | | | |
|---|---|---|---|
| | • Calculate three-dimensional Fourier transforms with appropriate examples.<br>• Utilize Fourier Transforms to solve one-dimensional wave and diffusion/heat flow equations in Physics applications. | | |
| **4** | • Find Laplace Transforms of 1st and 2nd order derivatives and integrals of functions, as well as derivatives and integrals of Laplace Transforms.<br>• Calculate Laplace Transforms for Unit Step function, Dirac Delta function, and periodic functions.<br>• Apply the Convolution Theorem and perform Inverse Laplace Transforms.<br>• Use Laplace Transforms to solve 2nd order differential equations in various physics-related scenarios, including damped harmonic oscillators, simple electrical circuits, and coupled differential equations.<br>• Apply Laplace Transforms to find the solution of heat flow along an infinite bar. | | |

| SCPH203 | Solid State Physics | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Crystallography | | | | |
| **Co-requisites** | Mathematical Physics | | | | |

**Course Objectives**

1. To acquire knowledge of crystal structure
2. Understanding the magnetic properties of matter
3. To enable them to understand of dielectric properties of Materials
4. To impart knowledge about semiconductor physics

On completion of this course, the students will be able to

**CO1:** Analyze crystal structures, bonding types, and defects in materials, and classify magnetic materials based on their properties.

**CO2:** Understand dielectric polarization, complex dielectric constant, and their variations with temperature and frequency, and apply dielectric properties in alternating electric fields.

**CO3:** Describe superconductivity phenomena, critical temperatures, and critical magnetic fields, and explain the Meissner effect in Type I and Type II superconductors.

**CO4:** Classify and compare different magnetic materials, explain hysteresis and energy loss in magnetic materials, and understand anti-ferromagnetism and ferrimagnetism.

**Catalog Description**

This course is intended to cover most of the basic topics of solid state including Crystal Structure, Space groups; Packing fraction, Miller indices,Defects in crystal,X-Ray Diffraction, Diamagnetism and Paramagnetism, Superconductivity. This course gives crystallographic knowledge and enables students to analyze the solid structures, which will also be beneficial for students in research field.

**Course Content**

**Unit I** **13 Lectures**

**Crystal Structure:** amorphous and crystalline materials, lattice translation vectors, lattice with a basis –unit cell, types of lattices symmetry elements, inter planer spacing, packing fraction, Miller Indices, Bonding in solids- ionic bond. covalent bond, metallic bonds, hydrogen bonding, van Der Waals bond, crystal defects , point defects, line defects, Burgers vector, surface imperfections.

**Unit II** **13 Lectures**

**Magnetic Properties of Matter:** Classification of Magnetic materials-Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia magnetic materials.Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains.Discussion of B-H Curve. Hysteresis and Energy Loss, antiferromagnetism, ferrimagnetism .

**Unit III** **14 Lectures**

**Dielectric Properties of Materials:** Types of Polarization, Local Electric Field at an Atom, static, Dielectric Constant, Electric Susceptibility, Polarizability, Classical Theory of Electric Polarizability, three vectors, Clausius-Mosotti Equation. Variation of dielectric polarization with temperature and frequency, pizo-pyro and ferroelectricity properties, domain theory of ferroelectricity, Complex Dielectric Constant, dielectrics in alternating fields, relaxation in dielectrics, absorption and losses, dielectric breakdowns.

**Unit IV** **14 Lectures**

**Superconductivity:** Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

**Text Books**

1. S O Pillai, Solid State Physics (New Age International Limited).
2. B.D. Cullity and C. D. Graham, Introduction to Magnetic Materials (John Wiley and Sons, Inc.)

**Reference Books/Materials**

1. B.D. Cullity, Elements of X-Ray Diffraction (Addison-Wesley Metallurgy Series).
2. Charles Kittel, Introduction to Solid State Physics (John Wiley and Sons, Inc.).
3. N. W. Ascroft and N. D. Mermin, Solid State Physics (Harcourt Asia, Singapore).

M. Ali Omar, Elementary solid state physics: principles and applications (Pearson Education)

**Open Educational Resources (OER)**

- **https://youtu.be/5h5gXoFyo64**
- **https://youtu.be/ax_rNTSI7ac**
- **https://youtu.be/63cwdYXNlYE**
- **https://youtu.be/sEGLcpmIIBY**
- **https://youtu.be/XrTJUAyolvE**
- **https://youtu.be/rkntp3_cZl4**
- **https://youtu.be/WV2AexANG34**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH203 Solid State Physics | CO1 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 1 | 2 |
| | CO2 | 2 | 3 | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2 |
| | CO3 | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 2 |
| | CO4 | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 1 | 2 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Crystal structure |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of crystal structures |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Magnetic properties of matter |
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding about magnetic properties of matter |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Dielectric properties of materials |
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of dielectric properties of matter |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |

| | |
|---|---|
| Environment & sustainability | - |
| Unit iv | Superconductivity |
| Local | - |
| Regional | - |
| National | - |
| Global | Deep understanding of semiconductors |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Projects and group discussion<br>Internship |

## Teaching Plan:

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| Week 1 | Crystal Structure | TB: S O Pillai, Ch. 1 | Lecture, Examples, Discussions |
| Week 2 | Bonding in Solids | TB: S O Pillai, Ch. 2 | Lecture, Examples, Discussions |
| Week 3 | Crystal Defects | TB: S O Pillai, Ch. 3 | Lecture, Examples, Discussions |
| Week 4 | Magnetic Properties of Matter | TB: B.D. Cullity and C. D. Graham, Ch. 1 | Lecture, Examples, Discussions |
| Week 5 | Dielectric Properties of Materials | TB: S O Pillai, Ch. 5 | Lecture, Examples, Discussions |
| Week 6 | Superconductivity | TB: S O Pillai, Ch. 6 | Lecture, Examples, Discussions |
| Week 7 | Crystal Structure (contd.) | RB: Charles Kittel, Ch. 1 | Lecture, Examples, Discussions |
| Week 8 | Magnetic Properties of Matter (contd.) | RB: Charles Kittel, Ch. 6 | Lecture, Examples, Discussions |
| Week 9 | Dielectric Properties of Materials (contd.) | RB: Charles Kittel, Ch. 9 | Lecture, Examples, Discussions |

| | | | |
|---|---|---|---|
| Week 10 | Superconductivity (contd.) | RB: Charles Kittel, Ch. 11 | Lecture, Examples, Discussions |
| Week 11 | Crystal Structure (contd.) | OER: https://youtu.be/5h5gXoFyo64 | Lecture, Examples, Discussions |
| Week 12 | Magnetic Properties of Matter (contd.) | OER: https://youtu.be/63cwdYXNlYE | Lecture, Examples, Discussions |
| Week 13 | Dielectric Properties of Materials (contd.) | OER: https://youtu.be/rkntp3_cZl4 | Lecture, Examples, Discussions |
| Week 14 | Superconductivity (contd.) | OER: https://youtu.be/WV2AexANG34 | Lecture, Examples, Discussions |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Students will be able to understand the fundamental concepts and principles of crystal structure, including the different types of lattices, symmetry elements, bonding in solids, and crystal defects. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Students will be able to analyze and explain the magnetic properties of matter, including the classification of magnetic materials, Curie's law, hysteresis, and the behavior of ferromagnetic, antiferromagnetic, and ferrimagnetic materials. | | |
| **3** | Students will be able to describe the dielectric properties of materials, including various types of polarization, dielectric constant, dielectric susceptibility, and the behavior of dielectrics in alternating fields. | | |
| **4** | Students will be able to comprehend the principles of superconductivity, including critical temperature, critical magnetic field, Meissner effect, and the differences between Type I and Type II superconductors. | | |

| **SCPH251** | SOLID STATE PHYSICS Lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | | | | | |
| **Pre-requisites/Exposure** | Solid State Physics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

- Learn the basics of dielectric properties of the materials.

- Develop an understanding of about Ferroelectric properties
- Understanding the source of magnetic behaviour of the materials and experimental verification.
- Experiments related to magnetism.

**Course Outcomes**

On completion of this course, the students will be able to

**CO1:** Apply the four-probe method to determine the band gap of an intrinsic semiconductor and analyze the experimental data.

**CO2:** Analyze hysteresis loss using a CRO and interpret the obtained waveforms to understand magnetic properties of the material. (Outcome Level: Analysis)

**CO3:** Measure the dielectric constant of a dielectric material using appropriate techniques and interpret the results to characterize the material's behavior in electric fields. (Outcome Level: Comprehension)

**CO4:** Conduct experiments to study the V-I characteristics of PN diodes and apply the obtained data to find the energy band gap of the PN junction diode.

**Catalog Description**

This course imparts the basic knowledge of construction of materials, microscopically. The course deals with the factors and conditions which are required to determine various properties like dielectric constant,magnetic susceptibility, semiconductor properties.. The course further delivers keen understanding of magnetism and its application in technology.

**Course Content**

**List of experiments**

1. To find the band gap of intrinsic semiconductor using four probe method.

2. To determine hysteresis loss using CRO

3. To measure the dielectric constant of a dielectric material

4. To study the variation of magnetic field with distance and to find the radius of coil

5. To study V-I characteristics of PN diode

6. To find the energy band gap of PN junction diode

7. To determine the value of Planck’s constant by photo cell

8. To find the value of Hall coefficient and carrier concentration of a semiconductor.

9. To measure the Magnetic field strength in solenoid

**Text book :**

1. Solid State Physics, S.O.PIllai, New Age Publication
2. Elements of X-Ray Diffraction, B.D. Cullity. Addison-Wesley Publishing Company,
3. Introduction to Magnetic Materials (2ndEdition,), B.D. Cullity and C.D. Graham, Wiley(2009)

**References Books:**

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer. Reference Books/Materials

**Open Educational Resources (OER)**

- https://youtu.be/KU3c5WaEwkI
- https://youtu.be/sSzpb6rOXx8
- https://youtu.be/N9wyxXo-c30
- https://youtu.be/_vKeaPHXF9U
- https://youtu.be/NKYBc7u6hO4
- https://youtu.be/gDFGj0Iodug
- https://youtu.be/RA_wGkUBetU
- https://youtu.be/2VkUMnl3dPk

**Assessment & Evaluation**

| **Components** | **Conduct of Experiment** | **Lab Record/Viva Voce** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcomes** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SCPH251, Solid State Physics Lab** | **CO1** | 2 | 2 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 2 |
| | **CO2** | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 3 |
| | **CO3** | 1 | 2 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 1 | 2 | 3 | 3 | 1 |
| | **CO4** | 2 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 3 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Solid state physics-i lab |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of crystals, magnetism and its application in technology.<br>- |
| Employability | - |
| Entrepreneurship | - |

| | |
|---|---|
| Skill development | Hands on experiments on physics instruments, data recording, data analysis and laboratory report writing |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4th IR | Use of software and simulations, hands on experience. |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook/Reference/OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Experiment 1: Band Gap of Semiconductors | TB: Solid State Physics - S.O. Pillai - Ch. X | Lecture, Discussion |
| 2 | Experiment 1 (contd.) | TB: Solid State Physics - S.O. Pillai - Ch. X | Lab Demonstration, Hands-on Activity |
| 3 | Experiment 2: Hysteresis Loss | OER: https://youtu.be/KU3c5WaEwkI | Video Lecture, Discussion |
| 4 | Experiment 3: Dielectric Constant | TB: Introduction to Solids - Leonid V. Azaroff | Lecture, Hands-on Measurement |
| 5 | Experiment 4: Magnetic Field | TB: Elements of Solid State Physics - J.P. Srivastava | Lecture, Calculation Practice |
| 6 | Experiment 5: V-I Characteristics | TB: Solid State Physics - N.W. Ashcroft and N.D. Mermin | Lecture, Lab Demonstration |
| 7 | Experiment 5 (contd.) | TB: Solid State Physics - N.W. Ashcroft and N.D. Mermin | Lab Work, Data Analysis |
| 8 | Experiment 6: Energy Band Gap | TB: Solid State Physics - N.W. Ashcroft and N.D. Mermin | Lecture, Calculation Practice |
| 9 | Experiment 7: Planck's Constant | OER: https://youtu.be/RA_wGkUBetU | Video Lecture, Discussion |
| 10 | Experiment 8: Hall Coefficient | TB: Solid State Physics - S.O. Pillai - Ch. Y | Lecture, Derivation Practice |
| 11 | Experiment 9: Magnetic Field Strength | TB: Introduction to Magnetic Materials - B.D. Cullity and C.D. Graham - Ch. Z | Lecture, Lab Demonstration |
| 12 | Recap and Revision | TB: Elements of X-Ray Diffraction - B.D. Cullity | Group Discussion, Q&A Session |
| 13 | Assessment and Problem Solving | RB: Introduction to Solid State Physics - Charles Kittel - Ch. P | Problem Solving, Practice Questions |
| 14 | Review and Conclusion | RB: Introduction to Solids - Leonid V. Azaroff | Group Discussion, Summary, Feedback |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Comprehend concepts of band gaps, electronic properties, and energy bands in semiconductors, exemplified by experiments like PN diode characteristics and energy band gap analysis. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Develop hands-on skills in conducting experiments, interpreting results, and relating them to theoretical principles, fostering an ability to apply physical concepts to real-world scenarios | | |
| **3** | Gain proficiency in utilizing diverse educational resources, fostering self-directed learning, and preparing for continuous exploration in solid-state physics and related fields. | | |
| **4** | Enhance critical thinking skills by analyzing complex experimental data, applying theoretical knowledge to solve problems, and developing the capacity to approach new challenges in the realm of solid-state physics. | | |

| **SCPH205** | Introduction of Nanochemistry and Applications | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

1. To be able to understand different classifications of nanomaterials.
2. To learn the experimental methods for synthesising nanomaterials.
3. To understand characterisation techniques that can be employed to study nano dimensions.
4. To develop a comprehensive knowledge about size dependent properties of nanoparticles.

**Course Outcomes**

On completion of this course, the students will be able to

**CO1:** Identify and categorize different types of nanostructures and nanomaterials based on their characteristics.
**CO2:** Analyze the size-dependent properties of nanomaterials and their implications in various fields.
**CO3:** Compare and contrast the different synthesis methods for nanomaterials and assess their advantages and limitations.
**CO4:** Utilize electron microscopy, diffraction, and other techniques to characterize nanomaterials, and apply this knowledge to practical applications in environmental remediation and biology.

**Catalog Description**

This course imparts the basic concepts of nanotechnology. It enables the students to understand the idea of synthesis and structural aspects of different types of nanomaterials. The course of nanochemistry will impart the knowledge about different characterisation techniques for nanomaterials. The course also introduces the use of nanoparticles in environmental remediation and biology.

**Course Content**

**Unit I: 8 Lectures**
Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures - Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

**Unit II: 12 Lectures**
Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

**Unit III: 12 Lectures**
Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures- control of nanoarchitecture- one dimensional control. Carbon nanotubes and inorganic nanowires.

**Unit IV: 8 Lectures**
Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).
**Text Books**

1. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004

**Reference Books/Materials**

1. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005
2. Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.
3. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

**Open Educational Resources**

- https://youtu.be/tlzlNg6xC5E
- https://youtu.be/zxjaXV10lnE
- https://youtu.be/NZrXDK5Plj4
- https://youtu.be/iOggL0Uurlw
- https://youtu.be/Z51R49OOqAA
- https://youtu.be/8YflxVwm6cE
- https://youtu.be/dSwvxLHAKKs

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH205 Introduction of Nanochemistry and Applications | CO1 | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| | CO2 | - | 3 | - | - | - | - | - | - | - | - | - | 3 | - | - |
| | CO3 | - | - | 3 | - | - | - | - | - | - | - | - | - | 3 | - |
| | CO4 | - | - | - | 2 | - | 3 | - | - | - | - | - | - | - | 3 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

# Teaching Plan:

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|

| | | | |
|---|---|---|---|
| | | | |
| 1 | Introduction to Nanoscience | TB1/RB1 | Lecture, Examples, Discussions |
| 2 | Nanostructures and Nanomaterials - Classification | TB1 | Lecture, Examples, Discussions |
| 3 | Calculation of Percentage & Surface-to-Volume Ratio | TB1 | Lecture |
| 4 | Size Dependent Properties - Quantum Confinement | TB1 | Lecture |
| 5 | Size Dependent Properties - Electrical & Optical | TB2 | Lecture |
| 6 | Size Dependent Properties - Magnetic & Thermal | TB2 | Lecture |
| 7 | Size Dependent Properties - Catalytic Properties | TB2 | Lecture, Examples, Discussions |
| 8 | Synthesis of Nanomaterials - Top-down & Bottom-up | TB2 | Lecture |
| 9 | Synthesis of Nanomaterials - Self-assembly Techniques | TB2 | Lecture |
| 10 | Synthesis of Nanomaterials - Solvothermal Process | TB1 | Lecture |
| 11 | Carbon Nanotubes and Inorganic Nanowires | TB1 | Lecture, Examples, Discussions |
| 12 | Material Characterization Techniques | TB1 | Lecture |
| 13 | Examples of Nanomaterials in Environmental Remediation & Biology | TB2 | Lecture, Examples, Discussions |
| 14 | Review and Recap | - | Discussion |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the fundamental concepts of nanoscience, nanostructure, and nanotechnology, including the classification of nanostructures and nanomaterials, and calculate the percentage of surface atom and surface-to-volume ratio of different-shaped nanoparticles. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Analyze the size-dependent properties of nanomaterials, such as quantum confinement, electrical, optical (Surface Plasmon resonance), color variations (Blue shift & Red shift), magnetic, thermal, and catalytic properties, with relevant | | |

| | | | |
|---|---|---|---|
| | examples. | to be encouraged to apply concepts to real world problems. | |
| **3** | Demonstrate knowledge of various synthesis methods for nanomaterials, including Top-down and Bottom-up approaches, self-assembly techniques, and the preparation of gold and silver metallic nanoparticles, as well as control of nanoarchitecture and one-dimensional control in self-assembled nanostructures, carbon nanotubes, and inorganic nanowires. | | |
| **4** | Familiarize with material characterization techniques, such as electron microscopy, diffraction, photoelectron spectroscopy, and zeta-potential measurement, and understand their applications in nanomaterial characterization. Explore practical examples of using nanomaterials in environmental remediation and biology. | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

| **SCPH207** | **Green Processes of Chemistry** | L | T | P | C |
|---|---|---|---|---|---|
| **Version 2.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | 12th level Chemistry | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

On completion of this course, the students will be able to understand

1. Green chemistry and its principles and processes in laboratory reactions.
2. Green synthesis and reactions.
3. Green chemistry for sustainable solutions.
4. Principles of green chemistry.
5. Design of chemical reactions/chemical synthesis using green chemistry principles.

**Course Outcomes**

**CO1:** By the end of this course, students will be able to: Understand the goals of Green Chemistry and identify the limitations and obstacles in achieving them.

**CO2:** Apply the twelve principles of Green Chemistry to design environmentally friendly chemical synthesis, focusing on waste prevention, atom economy, and materials incorporation.

**CO3:** Demonstrate knowledge of various green synthesis methods for specific chemicals and reactions, such as adipic acid, catechol, disodium iminodiacetate, and ultrasound-assisted reactions.

**CO4**: Analyze and evaluate the significance of Green Chemistry in developing environmentally safe products, including marine antifoulants, compostable plastics (poly lactic acid), and healthier fats and oils through enzymatic interesterification.

**Catalog Description**

Climate change and degradation of environment is a common global issue and sustainable development goals emphasize on reduction in pollution so as ensure better health, better sanitation and clean environment for all. Chemicals released from different industries as well as from chemical/ pharmaceutical labs add on to contaminants concentration in the environment. It is imperative to teach students the philosophy of green chemistry and how it can be helpful to reduce environmental pollution. Success stories and real world cases also motivate them to practice green chemistry. These

days customers are demanding to know about a product: Is it green? Does it contribute to global warming? Was it made from non-renewable resources?
Students have many career opportunities as " green" is the path to success.

**Course Content**

**UNIT I**

**Introduction to Green Chemistry** **4 Lectures**

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry

**UNIT II**

**Principles of Green Chemistry and Designing a Chemical synthesis** **12 Lectures**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

**UNIT III**

**Green Synthesis / Reactions** **16 Lectures**

Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).

1.Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).

2.Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

3.Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.

4.Designing of Environmentally safe marine antifoulant.

5.An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

6.Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils

**UNIT IV**

**Future Trends in Green Chemistry** **8 Lectures**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solvent less reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.

**Recommended Books/References**:


1. Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS (2000).
5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition, 2010.


**Open Educational Resources**

- **https://youtu.be/ESGFdKITnDg**
- **https://youtu.be/IuYtBR_XkQw**

- **https://youtu.be/FMHinRsfosU**
- **https://youtu.be/bsQBSVJoV04**
- **https://youtu.be/80kXSJqBYZg**
- Proliferation of Solventless Reactions - https://doi.org/10.1016/B978-0-12-817592-7.00014-9

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SCPH207** Green Processes of Chemistry | **CO1** | 3 | - | - | 1 | - | - | - | - | - | - | 3 | - | - | 1 |
| | **CO2** | - | 3 | - | - | - | 2 | - | - | - | - | - | 1 | - | - |
| | **CO3** | - | - | 3 | - | - | - | 2 | - | 1 | - | - | - | - | - |
| | **CO4** | - | - | - | 3 | - | - | - | - | - | 1 | 1 | - | 1 | 2 |

1=weakly mapped , 2= moderately mapped , 3=strongly mapped

## Teaching Plan:

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Introduction to Green Chemistry | TB - Chapter 1 | Lecture |
| | Goals of Green Chemistry, Limitations/Obstacles | | |
| 2 | Principles of Green Chemistry, Part 1 | TB - Chapter 2 (Principles 1-6) | Lecture |
| 3 | Principles of Green Chemistry, Part 2 | TB - Chapter 2 (Principles 7-12) | Lecture |
| | Designing a Green Synthesis | | |
| 4 | Green Synthesis of Adipic Acid, Catechol, Disodium Iminodiacetate | RB - Green Chemistry Journals | Discussion and Group Work |
| 5 | Microwave Assisted Reactions in Water | OER - Microwave-assisted Organic Synthesis | Laboratory and Demonstration |
| 6 | Reactions in Organic Solvents | OER - Green Chemistry Reactions | Laboratory and Demonstration |
| 7 | Ultrasound Assisted Reactions | OER - Sonochemical Synthesis | Laboratory and Demonstration |

| | | | |
|---|---|---|---|
| | Designing Environmentally Safe Marine Antifoulant | OER - Green Chemistry Applications | Discussion and Group Work |
| 8 | Green Synthesis of Compostable Plastic (PLA) | RB - Green Chemistry Journals | Laboratory and Discussion |
| | Healthier Fats and Oils through Green Chemistry | RB - Green Chemistry Applications | Lecture |
| 9 | Examination (Mid-Semester Assessment) | | Assessment |
| 10 | Oxidation Reagents and Catalysts | TB - Chapter 3 (Section 1) | Lecture |
| 11 | Biomimetic and Multifunctional Reagents | TB - Chapter 3 (Section 2) | Lecture |
| | Combinatorial Green Chemistry | TB - Chapter 3 (Section 3) | Lecture |
| 12 | Proliferation of Solventless Reactions | RB - Green Chemistry Journals | Discussion and Group Work |
| | Co-crystal Controlled Solid State Synthesis | RB - Green Chemistry Journals | Discussion and Group Work |
| 13 | Green Chemistry in Sustainable Development | TB - Chapter 4 | Lecture |
| 14 | Revision and Final Examination | | Assessment |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the goals and principles of Green Chemistry and identify the challenges in achieving them. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Apply the twelve principles of Green Chemistry to design environmentally friendly chemical synthesis methods, focusing on waste prevention and atom economy. | | |
| **3** | Demonstrate knowledge of various green synthesis techniques for specific chemicals and reactions, such as adipic acid, catechol, and ultrasound-assisted reactions. | | |
| **4** | Analyze and evaluate the significance of Green Chemistry in developing environmentally safe products, including marine antifoulants, compostable plastics (poly lactic acid), and healthier fats and oils through enzymatic interesterification. | | |

| **UNS103** | **Nanostructured materials** | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of nanomaterial | | | | |
| **Co-requisites** | -- | | | | |

**Course Description**

The aim of this course is make students understand the importance of nanostructured materials. Nanostructured materials have gained prominence in **technological advancements** due to their tunable physicochemical characteristics such as melting point, wettability, electrical and thermal conductivity, catalytic activity, light absorption and scattering resulting in enhanced performance over their bulk counterparts. Knowledge about these emerging materials will further help the students to explore these materials for advanced real life applications.

**Course Outcomes**

**CO1:** To recall the basics of Nano science and nanomaterial.

**CO2:** To understand about various applications of nanostructured materials

**CO3:** Analysing various technique for fabricating thin films

**CO4:** Evaluating the properties of Nano composites.

**Unit I: 10 Lectures**

Nano Composites and their Applications, Metal-Metal Nano composites for nuclear energy applications, Magnetic Nano composites for Spintronics application, Ceramic Nano composites for high temperature applications. Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures - Size effect and properties of nanostructures, Top down and Bottom up approach.

**Unit II: 10 Lectures**

Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nano polymers: Preparation and characterization of diblock Copolymer based Nano composites, Nanoparticles polymer ensembles; Applications of Nano polymers in Catalysis.

**Unit III: 10 Lectures**

Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

**Unit IV: 10 Lectures**

Miscellaneous applications of nanotechnology: dental implants, consumer products, biomimetic nanomaterial for tissue engineering, biopolymer tagging, semiconductor quantum dots.

**Thin Film Formation Methods**- Physical methods: thermal evaporation - vapour sources - Wire, crucible and electron beam gun - sputtering mechanism and methods - epitaxy - MBE. Chemical methods: chemical vapour deposition and chemical solution deposition techniques – spray pyrolysis - laser ablation

**Textbooks**

1. Materials Science and Engineering – An Introduction, William D Callister, 12th Edition, John Wiley

2. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.

**Reference Books**

Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor

2. Nanoscale materials -Liz Marzan and Kamat.

3. Physical properties of Carbon Nanotube-R Satio.

4. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.

5. Physics of Magnetism - S. Chikazumi and S.H. Charap.

6. Magnetostriction and Magnetomechanical Effects - E.W. Lee.

7. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell

**Open Educational Resources (OER)**

- https://youtu.be/6TprsnrvKIk
- https://youtu.be/j_wQgy97Pi4
- https://youtu.be/CJn2gXp3pyo
- https://youtu.be/TgwpVGWL6dQ
- https://youtu.be/nSAvyQajVzE
- https://youtu.be/mbOQYlBp0VQ
- https://youtu.be/ev1EiLWgDIs

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minor 3 Nanostructured materials | CO1 | 3 | 3 | - | - | - | - | - | - | - | - | 3 | 3 | - | - |
| | CO2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 3 | 2 | 3 | - |
| | CO3 | - | - | - | 2 | - | 2 | 2 | - | - | - | - | 2 | 3 | - |
| | CO4 | 1 | 1 | - | - | 2 | 1 | 1 | 2 | - | - | - | 2 | 2 | 1 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Nano Composites and their Applications |
|---|---|
| Local | Advancing regional capabilities in nanocomposite research and applications. |
| Regional | Contributing to national research and development in nanocomposites for energy and technology sectors. |
| National | Sharing knowledge of advanced nanocomposites for global energy and technology advancements. |
| Global | Equipping students with knowledge of nanocomposites relevant to emerging industries. |
| Employability | Fostering innovation in nanocomposite-related startups for niche applications. |

| | |
|---|---|
| Entrepreneurship | Developing skills in nanocomposite design, fabrication, and characterization. |
| Skill development | Encouraging ethical conduct in nanocomposite research and application development. |
| Professional ethics | Exploring the potential impact of nanocomposites, nanoceramics, and nanopolymers on gender-related issues. |
| Gender | Considering ethical and societal values in the development of nanocomposites. |
| Human values | Exploring sustainable applications of nanocomposites for environmental conservation. |
| Environment & sustainability | Exploring sustainable nanomaterials and their applications. |
| Unit ii | Nano ceramics |
| Local | Strengthening regional expertise in nanoceramics and nanopolymer development. |
| Regional | Enhancing national capabilities in nanoceramics, nanopolymer, and conducting polymer research. |
| National | Contributing to global research in nanoceramics, nanopolymer, and conducting polymer fields. |
| Global | Developing students' skills in nanoceramics, nanopolymer synthesis, and characterization. |
| Employability | Encouraging entrepreneurship in nanoceramics, nanopolymer, and conducting polymer sectors. |
| Entrepreneurship | Enhancing skills in nanoceramics, nanopolymer synthesis, and application development. |
| Skill development | Promoting ethical research and innovation in nanoceramics, nanopolymer, and conducting polymer fields. |
| Professional ethics | Investigating gender-inclusive approaches to nanotechnology applications and research. |

| | |
|---|---|
| Gender | Incorporating human values into nanoceramics, nanopolymer, and conducting polymer research. |
| Human values | Investigating environmentally friendly approaches in nanoceramics, nanopolymer, and conducting polymer development. |
| Environment & sustainability | Exploring quantum solutions for environmental challenges. |
| Unit iii | Classification of conducting polymers |
| Local | Promoting regional innovation in conducting polymer applications. |
| Regional | Advancing national research in conducting polymers for critical areas like energy devices. |
| National | Advancing global understanding of conducting polymers and their applications. |
| Global | Enhancing students' employability with expertise in conducting polymers for various sectors. |
| Employability | Supporting entrepreneurship in conducting polymer applications such as electronic devices. |
| Entrepreneurship | Developing expertise in conducting polymer synthesis and applications. |
| Skill development | Emphasizing ethical considerations in conducting polymer applications for safety and reliability. |
| Professional ethics | Addressing gender inclusivity in conducting polymer research and its applications. |
| Gender | Integrating human values into conducting polymer applications for societal benefit. |
| Human values | Promoting sustainable conducting polymer applications that align with environmental goals. |
| Environment & sustainability | Investigating sustainable nanomaterials and processes. |
| Unit iv | Miscellaneous applications of nanotechnology |
| Local | Investigating miscellaneous nanotechnology applications with local |

| | |
|---|---|
| | relevance, e.g., dental implants. |
| Regional | Supporting regional industries with diverse nanotechnology applications. |
| National | Promoting the adoption of nanotechnology in various national sectors through diverse applications. |
| Global | Exploring global applications of nanotechnology in areas like tissue engineering and biopolymer tagging. |
| Employability | Preparing students for careers in diverse nanotechnology applications globally. |
| Entrepreneurship | Promoting entrepreneurship in miscellaneous nanotechnology applications like semiconductor quantum dots. |
| Skill development | Developing skills in various thin film formation methods, both physical and chemical. |
| Professional ethics | Ensuring ethical practices in miscellaneous nanotechnology applications, especially in healthcare-related fields. |
| Gender | Considering gender perspectives in the development and application of miscellaneous nanotechnology products. |
| Human values | Reflecting human values in miscellaneous nanotechnology applications, especially those with healthcare implications. |
| Environment & sustainability | Ensuring the environmental sustainability of miscellaneous nanotechnology applications, such as biopolymer tagging. |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4$^{th}$ IR | Preparing students for the Fourth Industrial Revolution. |

# Teaching Plan:

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/Reference Book [RB]-Chapter/Page No./OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Unit I: Nano Composites and Applications | TB - Materials Science and Engineering, Ch. 1-2 | Lecture and Discussion |
| 2 | Unit I: Metal-Metal Nano composites | TB - Materials Science and Engineering, Ch. 4 | Lecture and Discussion |
| 3 | Unit I: Magnetic Nano composites | RB - Nanoscale materials, Ch. 5 | Lecture and Discussion |
| 4 | Unit I: Ceramic Nano composites | RB - Nanoscale materials, Ch. 6 | Lecture and Discussion |
| 5 | Unit I: Quantum confinement in nanostructures | TB - Materials Science and Engineering, Ch. 11 | Lecture and Discussion |
| 6 | Unit II: Nano ceramics | TB - Nanomaterials, Ch. 8 | Lecture and Discussion |
| 7 | Unit II: Nano polymers | TB - Nanomaterials, Ch. 9 | Lecture and Discussion |
| 8 | Unit III: Conducting polymers | RB - Polymer nanocomposites, Ch. 7 | Lecture and Discussion |
| 9 | Unit III: Applications of conducting polymers | RB - Polymer nanocomposites, Ch. 8 | Lecture and Discussion |
| 10 | Unit IV: Miscellaneous nanotechnology applications | RB - Carbon Nanotubes, Ch. 3 | Lecture and Discussion |
| 11 | Unit IV: Thin Film Formation - Physical methods | TB - Materials Science and Engineering, Ch. 17 | Lecture and Practical Demonstration |
| 12 | Unit IV: Thin Film Formation - Chemical methods | TB - Materials Science and Engineering, Ch. 18 | Lecture and Practical Demonstration |
| 13 | Unit IV: Thin Film Formation - Chemical methods | RB - Polymer nanocomposites, Ch. 10 | Lecture and Practical Demonstration |
| 14 | Unit IV: Thin Film Formation - Chemical methods | RB - Nanoscale materials, Ch. 9 | Lecture and Practical Demonstration |
| 15 | Unit IV: Thin Film Formation - Chemical methods | OER (Links provided) | Video Lectures |
| 16 | Revision and Recap | - | Review and Discussion |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the fundamentals of nanomaterials and nano composites, including their classifications, properties, and various applications in fields such as nuclear energy, spintronics, high-temperature environments, catalysis, and consumer products. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Analyze the principles of quantum confinement in semiconductor | | |

| | | | |
|---|---|---|---|
| | nanostructures and explain how size effects influence the properties of nanostructures in three-dimensional (3D), two-dimensional (2D), one-dimensional (1D), and zero-dimensional (0D) structures. | Students to be encouraged to apply concepts to real world problems. | |
| **3** | Evaluate the synthesis and characteristics of different nano materials, such as nano ceramics, nano polymers, and conducting polymers, and their application potential in fields such as dielectrics, ferroelectrics, magneto ceramics, sensors, electronic devices, and electrochemical energy devices. | | |
| **4** | Demonstrate knowledge and understanding of thin film formation methods, including physical methods like thermal evaporation, sputtering, and epitaxy, as well as chemical methods like chemical vapor deposition and chemical solution deposition, and apply this knowledge in real-world scenarios. | | |

| AEC003 | New Age Life Skills-III | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Basics of nanomaterial | | | | |
| **Co-requisites** | -- | | | | |

## Semester IV

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH202 | Modern Physics | 4 |
| 2 | SCPH204 | Waves and Optics | 4 |
| 3 | SCPH252 | Waves and Optics Lab | 1 |
| 4 | | Select one course from a basket of course | 3 |
| 5 | | Select one course from a basket of course | 2 |
| 6 | SEC017 | Documentation using Latex | 2 |
| 7 | UNS104 | Crystallography | 4 |
| 8 | UNS105 | Crystallography Lab | 1 |
| | SIPH002 | Summer Internship /Project | |
| TOTAL | | | 21 |

| **SCPH202** | **MODERN PHYSICS** | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of nanomaterial | | | | |

| | |
|---|---|
| **Co-requisites** | -- |

Couse Objectives

1. Understand the structure of the atom
2. Explore the particle properties of waves
3. Examine the wave properties of particles.
4. Study nuclear transformations
5. Investigate artificial transmutation of elements

Course Outcomes:

**CO1:** Understand the fundamental structure and behavior of atoms
**CO2:** Comprehend the dual nature of particles
**CO3:** Analyze nuclear transformations and reactions
**CO4:** Apply knowledge to artificial transmutation and neutron-related topics

**UNIT-I** 14 Lectures

**Structure of the Atom**

Rutherford's Experiments on Scattering of α-particles; Theory of α-particle Scattering; Bohr Atom Model; Effect of Nuclear Motion on Atomic Spectra; Evidences in Favour of Bohr's Theory; Correspondence Principle; Critical Potentials; Sommerfeld's Relativistic Atom Model; The Vector Atom Model; Quantum Numbers Associated with the Vector Atom Model; The Pauli Exclusion Principle; The Periodic Classification of Elements; Magnetic Dipole Moment due to Orbital Motion of the Electron; Magnetic Dipole Moment due to Spin; Zeeman Effect; Larmor's Theorem; Stark Effect.

**UNIT-II** 13 Lectures

**Particle properties of Waves:** Electromagnetic waves,Blackbody Radiation, Photo-electric effect, Einstein's Photoelectric Equation, Compton scattering, pair production, photons and gravity.

**Wave properties of the Particles:** De Broglie waves, description of wave, Probability. Wave amplitude and wave functions, Group and Phase velocities and relation between them, Davisson-Germer experiment, Heisenberg uncertainty principle.

**UNIT-III** 14 Lectures

**Nuclear Transformations**

stability of the nucleus; Law of radioactive decay; Mean life and half-life; types of radio active decays, Alpha decay; Beta decay, Gamma ray emission, positron emission and electron capture, radioactive series, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus, nuclear reactions and Q values.

Nuclear Fission; Energy Released in Fission; Chain Reaction; Atom Bomb; Nuclear Reactors; Nuclear Fusion, Source of Stellar Energy; Thermonuclear reactions

**UNIT IV** 13 Lectures

**Artificial Transmutation of Elements**

The Discovery of Artificial Transmutation; Bohr's Theory of Nuclear Disintegration, nuclear reactions; The Q-Value Equation for a Nuclear Reaction; Nuclear Reactions; Energy Balance in Nuclear Reactions and the Q-value; Threshold Energy of an Endoergic Reaction; Nuclear Transmutations; The Scattering Cross-Section; Discovery; Preparation of Radioelements; Applications of Radioisotopes; The Discovery of the Neutron; Basic Properties of the Neutron;

Classification of Neutrons; Neutron Sources; Neutron Detection; Neutron Collimator.

**Text Books**


1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Modern Physics (17th Ed.), 2013, S. Chand & Company Pvt. Ltd.


**Reference Books/Materials**


1. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
2. Textbook of engineering Physics, M.N Avadhanulu, P.G.Kshirsagar.

3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan 2002.

**Open Educational Resources (OER)**

- https://www.youtube.com/live/uFF_ptEDN0o?feature=share
- https://youtu.be/3It49x562b0
- https://youtu.be/UyWXOIK0uSg
- https://youtu.be/QpXIPPln3Ig
- https://youtu.be/Hpn5G1FiuCs
- https://youtu.be/Lhxx2jQmLH4
- https://youtu.be/PNBk5LjweEk

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | Course Outcomes | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH202 Modern Physics | CO1 | 3 | 2 | - | - | - | 3 | - | - | - | 3 | 3 | - | - | - |
| | CO2 | 3 | 2 | - | - | - | 3 | - | - | - | 3 | 3 | - | - | - |
| | CO3 | 3 | - | 2 | - | - | 3 | - | - | - | 2 | 3 | - | - | - |
| | CO4 | 3 | 2 | - | - | - | 3 | - | - | - | 2 | 3 | - | - | - |

1=weakly mapped
2= moderately mapped
3=strongly mapped

## Teaching Plan

| **Week** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ OER** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Structure of the Atom | TB: Concepts of Modern Physics - Chapter 1 | Lecture and Discussion |
| 2 | Structure of the Atom | TB: Concepts of Modern Physics - Chapter 2 | Lecture and Discussion |
| 3 | Structure of the Atom | TB: Concepts of Modern Physics - Chapter 3 | Lecture and Discussion |
| 4 | Particle properties of Waves | TB: Concepts of Modern Physics - Chapter 4 | Lecture and Discussion |
| 5 | Particle properties of Waves | TB: Concepts of Modern Physics - Chapter 5 | Lecture and Discussion |
| 6 | Nuclear Transformations | TB: Concepts of Modern | Lecture and Discussion |

| | | | |
|---|---|---|---|
| | | Physics - Chapter 6 | |
| 7 | Nuclear Transformations | TB: Concepts of Modern Physics - Chapter 7 | Lecture and Discussion |
| 8 | Nuclear Transformations | TB: Concepts of Modern Physics - Chapter 8 | Lecture and Discussion |
| 9 | Artificial Transmutation of Elements | TB: Concepts of Modern Physics - Chapter 9 | Lecture and Discussion |
| 10 | Artificial Transmutation of Elements | TB: Concepts of Modern Physics - Chapter 10 | Lecture and Discussion |
| 11 | Artificial Transmutation of Elements | RB: Introduction to Quantum Mechanics - Chapter 1 | Lecture and Discussion |
| 12 | Artificial Transmutation of Elements | RB: Introduction to Quantum Mechanics - Chapter 2 | Lecture and Discussion |
| 13 | Review and Recap | TB: Concepts of Modern Physics - Chapters 1-10 | Lectures, Discussions, Q&A |
| 14 | Revision and Assessment | Comprehensive Review and Assessment of the Course Topics | Lectures, Discussions, Q&A, Exam |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the fundamental principles of atomic structure and behavior, including Rutherford's experiments on scattering alpha particles, Bohr's atom model, and the effects of nuclear motion on atomic spectra. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Comprehend the wave-particle duality concept, including the particle properties of waves (e.g., electromagnetic waves) and the wave properties of particles (e.g., De Broglie waves). Understand the Davisson-Germer experiment and the Heisenberg uncertainty principle. | | |
| **3** | Analyze nuclear transformations and decay processes, including the stability of nuclei, radioactive decay laws, types of radioactive decays (alpha, beta, gamma, positron emission, and electron capture), and energy-momentum conservation in nuclear reactions. | | |
| **4** | Apply knowledge of nuclear reactions and artificial transmutation of elements, including understanding Bohr's theory of nuclear disintegration, Q-value equation for nuclear reactions, and preparation and | | |

| | | | |
|---|---|---|---|
| | applications of radioisotopes. Understand the basics of nuclear fission, nuclear fusion, and thermonuclear reactions. | | |

| **SCPH204** | Waves and Optics | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Electromagnetic Theory | | | | |
| **Co-requisites** | Electrostatics and Electromagnetism | | | | |

**Course Objectives**

3. To learn about the Simple Harmonic Oscillation and its solution
4. To understand the different wave's phenomenon
5. To understand the behaviour and properties of light
6. To acquire knowledge of interference diffraction, polarisation and Holography

**Course Outcomes**

On completion of this course, the students will be able to

**CO1**: Understand principles of superposition, collinear harmonic oscillations, wave motion, and wave optics.

**CO2**: Apply graphical and analytical methods to study superposition of perpendicular harmonic oscillations and interference in thin films.

**CO3**: Analyze standing waves in strings and pipes, and interpret diffraction patterns in various scenarios.

**CO4**: Comprehend the principles of interferometers and holography, and evaluate their significance and applications.

**Catalog Description**

This course builds on the ideas of harmonic motion to cover in depth the concept of waves in physics with particular emphasis on light waves as an example. Emphasis will be on the optical phenomena associated with Wave Optics for example Interference, Diffraction and Polarisation.

**Course Content**

**UNIT-I** **14 Lecture Hours**

**Superposition of Collinear Harmonic oscillations:** Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

**Superposition of two perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

**Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive

(Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

**UNIT-II** **13 Lecture Hours**

**Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

**Superposition of Two Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

**UNIT-III** **14 Lecture Hours**

**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

**Interference:** Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

**Interferometer:** Michelson Interferometer-(1) Idea of form of fringes (No theoryrequired), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

**UNIT-IV** **13 Lecture Hours**

**Diffraction:** Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)

**Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

**Fresnel Diffraction:** Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

**Holography:** Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

**Reference Books:**


- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.


**Open Educational Resources (OER)**

- **https://youtu.be/JWfYzyPvYNU**
- **https://youtu.be/xjiS1lblx_c**
- **https://youtu.be/iWSNa8BCgaI**
- **https://youtu.be/420N11Vuf_g**
- **https://youtu.be/nzwHI6UUnuA**

- **https://youtu.be/mL63s4QqVPc**
- **https://youtu.be/hpLADfPpXwg**
- **https://youtu.be/-qngILxqGX0**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Couse Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Waves and Optics and SCPH204 | CO1 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 |
| | CO2 | 2 | 3 | 2 | 3 | 1 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |
| | CO3 | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| | CO4 | 2 | 2 | 2 | 3 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Superposition of harmonic oscillations, wave motion |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Understand the behaviour and properties of waves such as light waves |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Velocity of waves, superposition of two harmonic waves |
| Local | - |
| Regional | - |
| National | - |
| Global | Understand the behaviour and properties of waves such as light waves |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Wave optics, interference, interferometer |
| Local | - |
| Regional | - |

| | |
|---|---|
| National | - |
| Global | Knowledge of various wave optics phenomena such as interference, diffraction, polarisation and holography |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Diffraction |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of various wave optics phenomena such as interference, diffraction, polarisation and holography |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Promoting high-quality research |
| Poe/4$^{th}$ IR | Projects and group discussion |

**Teaching Plan**

| Week | Unit No. | Topic Name | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|---|
| 1 | Unit-I | Superposition of Collinear Harmonic Oscillations | TB: Waves - Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill | Lecture |
| 2 | Unit-I | Beats | TB: Waves - Chapter 1 | Lecture |
| 3 | Unit-I | Superposition of N Collinear Harmonic Oscillations | TB: Waves - Chapter 2 | Lecture |
| 4 | Unit-I | Superposition of Two Perpendicular Harmonic Oscillations | TB: Waves - Chapter 3 | Lecture |

| | | | | |
|---|---|---|---|---|
| 5 | Unit-I | Lissajous Figures and Their Uses | TB: Waves - Chapter 4 | Lecture |
| 6 | Unit-II | Wave Motion | TB: Waves - Chapter 5 | Lecture |
| 7 | Unit-II | Plane and Spherical Waves | TB: Waves - Chapter 6 | Lecture |
| 8 | Unit-II | Plane Progressive (Travelling) Waves | TB: Waves - Chapter 7 | Lecture |
| 9 | Unit-II | Wave Equation and Particle Velocities | TB: Waves - Chapter 8 | Lecture |
| 10 | Unit-III | Velocity of Waves | TB: Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill | Lecture |
| 11 | Unit-III | Superposition of Two Harmonic Waves | TB: Fundamentals of Optics - Chapter 1 | Lecture |
| 12 | Unit-III | Phase and Group Velocities | TB: Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press | Lecture |
| 13 | Unit-IV | Changes with respect to Position and Time | TB: Principles of Optics - Chapter 1 | Lecture |
| 14 | Unit-IV | Energy of Vibrating String | OER: https://youtu.be/JWfYzyPvYNU | Video Lecture |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the principles of superposition, harmonics, and wave motion, and their applications in various physical systems. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Analyze and interpret interference, diffraction, and holography phenomena, and their implications in optics and wave-based technologies. | | |
| **3** | Apply graphical and analytical methods to study the behavior of waves in different configurations, such as standing waves and Lissajous figures. | | |
| **4** | Develop problem-solving and investigative skills in the field of physics, enabling the analysis of complex wave-related problems and the use of mathematical modeling for | | |

| | | | |
|---|---|---|---|
| | practical applications. | | |

| SCPH252 | Waves and Optics Lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 4 | 2 |
| **Pre-requisites/Exposure** | Waves and Optics | | | | |
| **Co-requisites** | Electromagnetic Theory | | | | |

**Course Objectives**

7. To learn about the experimental set ups related to various optical phenomena.
8. To learn the wave equation an its solution.
9. To understand the behaviour and properties of light.
10. To acquire knowledge of interference, diffraction, polarisation and Holography

**Course Outcomes**

On completion of this course, the students will be able to

CO1. Explain different laboratory instruments and their uses in optics lab.

CO2. Understand various optical phenomena i.e. Interference, Diffraction and Polarisation using hands on experiments.

CO3. Apply various wave optics phenomena such as Interference, Diffraction, Polarisation and Holography to evaluate various physical parameters.

CO4. Identify and evaluate the errors involved.

**List of Experiments**

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2$ –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

**Reference Books:**


- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.


**Open Educational Resources**

- **https://youtu.be/hwWPDqHFxOg**
- **https://youtu.be/tnQn994Eqm8**
- **https://youtu.be/e4poHiwoTH8**
- **https://youtu.be/S3PiJ0PQghc**
- **https://youtu.be/JvVOaqej1II**
- **https://youtu.be/tQj5v74Q8p0**
- **https://youtu.be/1Qc-HIml-U4**
- **https://youtu.be/fWhgguWc8rk**

**Assessment & Evaluation**

| **Components** | **Conduct of Experiment** | **Lab Record/Viva Voce** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Couse Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH252 and Waves and Optics Lab | CO1 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 |
| | CO2 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| | CO3 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 1 | 2 | 3 |
| | CO4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 2 |

1=weakly mapped
2= moderately mapped
3=strongly mapped

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Waves and optics lab |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Deep knowledge of waves and optical phenomena associated with wave optics through lab experiments |
| Employability | Experimental set ups related to various optical phenomena such as interference, diffraction, polarisation and holography |
| Entrepreneurship | - |
| Skill development | Experimental set ups related to various optical phenomena such as interference, diffraction, polarisation and holography |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |

| | |
|---|---|
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Promoting high quality research |
| Poe/4th IR | Hands on experience, projects, internship |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook/Reference | Teaching-Learning Method |
|---|---|---|---|
| 1 | Experiment 1 | TB: Ch. X | Lecture, Demonstration |
| 2 | Experiment 1 | OER: Link 1 | Practical Lab Session |
| 3 | Experiment 2 | TB: Ch. X | Lecture, Discussion |
| 4 | Experiment 2 | OER: Link 2 | Practical Lab Session |
| 5 | Experiment 3 | TB: Ch. X | Lecture, Demonstration |
| 6 | Experiment 3 | OER: Link 3 | Practical Lab Session |
| 7 | Experiment 4 | TB: Ch. X | Lecture, Discussion |
| 8 | Experiment 4 | OER: Link 4 | Practical Lab Session |

| | | | |
|---|---|---|---|
| 9 | Experiment 5 | TB: Ch. X | Lecture, Demonstration |
| 10 | Experiment 5 | OER: Link 5 | Practical Lab Session |
| 11 | Experiment 6 | TB: Ch. X | Lecture, Discussion |
| 12 | Experiment 6 | OER: Link 6 | Practical Lab Session |
| 13 | Experiment 7 | TB: Ch. X | Lecture, Demonstration |
| 14 | Experiment 7 | OER: Link 7 | Practical Lab Session |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Learn to verify wave laws, like λ^2 – T law, by determining tuning fork frequencies, building a strong foundation in experimental optics. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Investigate coupled oscillators, unraveling the dynamic interplay between interconnected systems and enhancing analytical skills | | |
| **3** | Study Lissajous Figures to enhance wave pattern visualization and analysis skills, crucial in diverse | | |

| | | | |
|---|---|---|---|
| | scientific and engineering applications | | |
| **4** | Gain proficiency in optics by exploring properties like refractive indices, dispersive power, and resolving power, with applications ranging from materials to light sources. | | |

| **UNS104** | Crystallography | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Solid State Physics | | | | |
| **Co-requisites** | Basic knowledge in Materials Science | | | | |

**Course Description**

This course is an introduction to the principles of structure of materials, and theory and applications of diffraction and imaging techniques for materials characterization using X-ray diffraction and transmission electron microscopy (TEM).

**Course Outcomes**

CO1: Analyze and interpret the key principles of geometric crystallography, including the properties of crystalline matter, the application of symmetry operations, and understanding of crystallographic notations.

CO2: Compare and contrast various crystal structures, apply principles that govern the formation of these structures, and utilize X-ray diffraction methods to investigate structural variations.

CO3: Investigate and articulate the relationship between the physical properties of crystals and their crystalline symmetry, demonstrating an understanding of optical properties and how they're observed and determined.

CO4: Evaluate the impact of crystal defects and dynamics on the physical properties of crystals, and develop a comprehensive understanding of crystal formation, growth, and real crystal morphology.

**Course Content**

**Unit 1.**

**Geometric crystallography:** Historical development of Crystallography, The periodic table of the elements and interatomic bonds, Order and periodicity. Properties of crystalline matter, Crystal networks. Periodic two-dimensional networks. Bravais networks and crystalline systems. Elements of the periodic networks, Crystallographic notations: knots rows and planes. Weiss parameters and Miller indices, Relationship between morphology and structure, Crystallographic areas, Symmetry operations in 2 and 3 dimensions, The 32 specific groups. Crystal systems and symmetry, Crystal morphology.

**Unit 2.**

**Structural crystallography and crystal chemistry** : The symmetry of the unit cell., Space groups, Atomic positions and structural positions, Crystal structures, Principles that govern the formation of crystalline structures, Variations in the chemical composition of the crystals. Isomorphism, solid solutions and stoichiometry, X-ray diffraction by crystals. Difraction methods: fundamentals and information they provide.

**Unit 3.**

**Physical properties of crystals:** Introduction to the physical properties of crystals, and their relation to crystalline symmetry. Optical properties, Nature of light, and other basic concepts, Optical properties,Isotropy and optical anisotropy. The optical surfaces. , Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer. Optical determinations with parallel light and analyzer. Optical determinations with convergent light.

**Unit 4.**

**Crystal Dynamics** : The real crystal. Crystal defects and crystalline dynamics. Influence of defects on the physical properties of crystals, Crystal defects: punctual, linear, two-dimensional and three-dimensional. Crystal formation and growth. Morphology of the real crystal. Add and twins. Polymorphism

**Textbook**: David B. Williams and C. Barry Carter, *Transmission Electron Microscopy: A Textbook for Materials Science*, Plenum Press, NY (2007). (Required)

**Reference Books**

Introduction to Solid State Physics - C. Kittel
Principles of Solid State Physics - R. A. Levy Solid State Physics- S.O. Pillai
Elements of X-Ray diffraction - B.D. Cullity
Elementary Solid State Physics - Ali Omar
Elements of Solid State Physics - J.P. Srivastava
Nano; The Essentials By T. Pradeep (Tata McGraw Hill Publ)

**Open Education Resources**

- Introduction to Crystallography and Mineral Crystal Systems - A comprehensive overview of geometric crystallography.
- Crystallography Open Database - A database of crystal structures.
- MIT OpenCourseWare - Crystal Structure Reading Collection - Reading materials on crystal structures.
- Fundamentals of Crystallography - An article on the principles that govern the formation of crystalline structures.
- Introduction to Crystal Physics - A detailed course on the physical properties of crystals.
- Crystalline Materials - Explains the optical properties of crystals.
- Solid State Physics - A chapter on crystal defects and dynamics from a course on solid state physics.
- Crystal Growth & Design - A journal with open access articles on crystal formation and growth.

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme and Course Mapping**

| Course Code & Title | Course Outcomes (CO) | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS104 Crystallography | CO1 | 3 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 1 | 2 |
| | CO2 | 3 | 2 | 1 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 2 | 2 |
| | CO3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 3 |
| | CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

**Unit 1: Geometric Crystallography**

| Indicator | Relevant Course Content |
|---|---|
| Local | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| Regional | - |
| National | Historical development of Crystallography, Properties of crystalline matter, Crystal |

| | |
|---|---|
| | networks, Crystallographic notations: knots rows and planes, Symmetry operations in 2 and 3 dimensions, The 32 specific groups, The symmetry of the unit cell, Atomic positions and structural positions |
| Global | Historical development of Crystallography, Properties of crystalline matter, Crystal networks, Crystallographic notations: knots rows and planes, Symmetry operations in 2 and 3 dimensions, The 32 specific groups, The symmetry of the unit cell, Atomic positions and structural positions |
| Employability | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| Entrepreneurship | - |
| Skill Development | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| Professional Ethics | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| Gender | - |
| Human Values | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| Environment & Sustainability | Symmetry operations in 2 and 3 dimensions, Crystal morphology |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

**Unit 2: Structural Crystallography and Crystal Chemistry**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | The symmetry of the unit cell, Variations in the chemical composition of the crystals, X-ray diffraction by crystals, Diffraction methods: fundamentals and information they provide |
| Regional | - |
| National | The symmetry of the unit cell, Variations in the chemical composition of the crystals, Isomorphism, solid solutions, and stoichiometry, X-ray diffraction by crystals, |
| Global | The symmetry of the unit cell, solid solutions, and stoichiometry, X-ray diffraction by crystals, Diffraction methods: fundamentals and information they provide, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, The real crystal, Influence of defects on the physical properties of crystals |
| Employability | The real crystal |
| Entrepreneurship | - |
| Skill Development | The real crystal |
| Professional Ethics | The real crystal |
| Gender | - |
| Human Values | The real crystal |
| Environment & Sustainability | The real crystal |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

**Unit 3: Physical Properties of Crystals**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | - |
| Regional | - |
| National | Introduction to the physical properties of crystals, and their relation to crystalline symmetry, Optical properties, Nature of light, and other basic concepts, Optical properties, Isotropy and optical anisotropy, The optical surfaces, Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer, Optical determinations with parallel light and analyzer, Optical determinations with convergent light |
| Global | Introduction to the physical properties of crystals, and their relation to crystalline symmetry, Optical properties, Nature of light, and other basic concepts, Optical properties, Isotropy and optical anisotropy, The optical surfaces, Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer, Optical determinations with parallel light and analyzer, Optical determinations with convergent light |

| | |
|---|---|
| Employability | - |
| Entrepreneurship | - |
| Skill Development | - |
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

**Unit 4: Crystal Dynamics**

| Indicator | Relevant Course Content |
|---|---|
| Local | - |
| Regional | - |
| National | The real crystal, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, Influence of defects on the physical properties of crystals, Crystal formation and growth, Morphology of the real crystal, Add and twins, Polymorphism |
| Global | The real crystal, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, Influence of defects on the physical properties of crystals, Crystal formation and growth, Morphology of the real crystal, Add and twins, Polymorphism |
| Employability | The real crystal |
| Entrepreneurship | - |
| Skill Development | The real crystal |
| Professional Ethics | The real crystal |
| Gender | - |
| Human Values | The real crystal |
| Environment & Sustainability | The real crystal |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

## Teaching Plan:

| Week | Topics | Reference Books/Open Education Resources | Teaching Learning Method |
|---|---|---|---|
| Week 1 | Introduction and Historical Development of Crystallography | C. Kittel, Introduction to Solid State Physics, Webmineral: Crystallography | Lectures |
| Week 2 | The Periodic Table of the Elements and Interatomic Bonds | David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science | Lectures and Group Discussions |
| Week 3 | Order and Periodicity, Properties of Crystalline Matter | R. A. Levy, Principles of Solid State Physics, MIT OpenCourseWare: Solid State Physics | Lectures and Demonstrations |
| Week 4 | Crystal Networks, Periodic Two-Dimensional Networks | S.O. Pillai, Solid State Physics, MIT OpenCourseWare: Crystal Structures | Lectures and Practical Lab Sessions |
| Week 5 | Bravais Networks and Crystalline Systems | B.D. Cullity, Elements of X-Ray Diffraction, Crystallography Open | Lectures and Group Discussions |

| | | | |
|---|---|---|---|
| | | Database | |
| Week 6 | Elements of the Periodic Networks, Crystallographic Notations | Ali Omar, Elementary Solid State Physics, Crystallography and Minerals Arranged by Crystal Form | Lectures and Demonstrations |
| Week 7 | Crystallographic notations: knots rows and planes. Weiss parameters and Miller indices, Relationship between morphology and structure, Crystallogra | Transmission Electron Microscopy: A Textbook for Materials Science Fundamentals of Crystallography - An article on the principles that govern the formation of crystalline structures. | Review Sessions and Examinations |
| Week 8 | Symmetry Operations in 2 and 3 Dimensions, The 32 Specific Groups | J.P. Srivastava, Elements of Solid State Physics, Crystallography in Real Life | Lectures and Group Discussions |
| Week 9 | Crystal Systems and Symmetry, Crystal Morphology | T. Pradeep, Nano; The Essentials, Crystallography Matters! | Lectures and Demonstrations |
| Week 10 | The Symmetry of the Unit Cell, Space Groups | C. Kittel, Introduction to Solid State Physics, Lecture on Crystallography | Lectures and Practical Lab Sessions |
| Week 11 | Atomic Positions and Structural Positions, Crystal Structures | R. A. Levy, Principles of Solid State Physics, Structural Crystallography: An Introduction | Lectures and Demonstrations |
| Week 12 | Introduction to the Physical Properties of Crystals and their Relation to Crystalline Symmetry | S.O. Pillai, Solid State Physics, The Physics of Crystals | Lectures and Group Discussions |
| Week 13 | The Real Crystal, Crystal Defects and Crystalline Dynamics | David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Crystalline Materials | Lectures and Practical Lab Sessions |
| Week 14 | Crystal formation and growth. Morphology of the real crystal. | David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Crystalline Materials | Lectures |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Course Learning Outcomes (CLO) | Teaching Learning Activity (TLA) | Assessment Task Methods (ATM) |
|---|---|---|---|
| Unit 1 | Analyze and interpret the key principles of geometric crystallography, including the properties of crystalline matter, the application of symmetry operations, and understanding of crystallographic notations. | Lectures and demonstrations, self-study, guided group discussion. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| Unit 2 | Compare and contrast various crystal structures, apply principles that govern the formation of these structures, and utilize X-ray diffraction methods to investigate structural variations. | Practical lab sessions, problem-solving sessions, guided reading. | |
| Unit 3 | Investigate and articulate the relationship between the physical properties of crystals and their crystalline symmetry, demonstrating an understanding of optical properties and how they're observed and determined. | Demonstrations of physical properties of crystals, group discussions on optical properties, practical sessions on observation techniques. | |

| | | | |
|---|---|---|---|
| Unit 4 | Evaluate the impact of crystal defects and dynamics on the physical properties of crystals, and develop a comprehensive understanding of crystal formation, growth, and real crystal morphology. | Case study analysis, collaborative group work on specific topics, self-study on crystal defects. | |

| | | | | | |
|---|---|---|---|---|---|
| **UNS105** | Crystallography lab | L | T | P | C |
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 30 | | | | |
| **Pre-requisites/Exposure** | Solid State Physics | | | | |
| **Co-requisites** | Basic knowledge in Materials Science | | | | |

**Course Description**

This course is an introduction to study of structure of materials, coordination number, bond lengths etc using Diamond software

**Course Outcomes**

CO1: Describe the theoretical foundations of crystallography.
CO2: Understand the properties and symmetry of crystals.
CO3: Analyze the bonding between atoms.
CO4: Evaluation of the Coordination number

**Course Content**

List of experiments

1. To Study the structure of Simple cubic crystal system.
2. To Study the structure of Body centered cubic crystal system
3. To Study the structure of Face centered cubic crystal system
4. To Study the structure of tetragonal crystal system
5. To Study the structure of Orthorhombic crystal system
6. To Study the structure of Rhombohedral crystal system
7. To Study the structure of Hexagonal crystal system
8. To Study the structure of monoclinic Crystal system
9. To Study the structure of Triclinic crystal system
10. To Study the structure of Perovskites.

**Reference Books**


- Introduction to Solid State Physics - C. Kittel
- Principles of Solid State Physics - R. A. Levy
- Solid State Physics- S.O. Pillai
- Elements of X-Ray diffraction - B.D. Cullity
- Elementary Solid State Physics - Ali Omar
- Elements of Solid State Physics - J.P. Srivastava
- Nano; The Essentials By T. Pradeep (Tata McGraw Hill Publ)


**Open Educational Resources (OER)**

- https://youtu.be/HCWwRh5CXYU
- https://youtu.be/_9RnbGqtkd4

- https://youtu.be/GSPVC34ijIA
- https://youtu.be/JS9ysbgr0BE
- https://youtu.be/07iZ7-IEyYE

**Assessment & Evaluation**

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme and Course Mapping**

| Course Code & Title | Course Outcomes (CO) | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS105 Crystallography | CO1 | 3 | 2 | 1 | 2 | 1 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| | CO2 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| | CO3 | 3 | 2 | 1 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 |
| | CO4 | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 |

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Indicator | Relevant Course Content |
|---|---|
| Local | To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of Triclinic crystal system, To Study the structure of Perovskites |
| Regional | - |
| National | To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of Triclinic crystal system, To Study the structure of Perovskites |
| Global | To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic |

| | |
|---|---|
| | crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of Triclinic crystal system, To Study the structure of Perovskites |
| Employability | - |
| Entrepreneurship | - |
| Skill Development | - |
| Professional Ethics | - |
| Gender | - |
| Human Values | - |
| Environment & Sustainability | - |
| SDG | - |
| Nep 2020 | - |
| Poe/4th IR | - |

## Teaching Plan:

| Week | Topic/Unit No. | Textbook/Reference | Teaching-Learning Method |
|---|---|---|---|
| 1 | Introduction to Crystal Systems | TB - Introduction to Solid State Physics - C. Kittel, Ch. 1, OER1 | Lecture, Demonstration |
| 2 | Simple Cubic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER1 | Practical Lab Session |
| 3 | Body Centered Cubic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER2 | Lecture, Discussion |
| 4 | Face Centered Cubic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER 3 | Practical Lab Session |

| | | | |
|---|---|---|---|
| 5 | Tetragonal Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER4 | Lecture, Demonstration |
| 6 | Orthorhombic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER 4 | Practical Lab Session |
| 7 | Rhombohedral Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER 4 | Lecture, Discussion |
| 8 | Hexagonal Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4 | Practical Lab Session |
| 9 | Monoclinic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4 | Lecture, Demonstration |
| 10 | Triclinic Crystal System | TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4 | Practical Lab Session |
| 11 | Perovskites Structure | RB - Nano; The Essentials By T. Pradeep, Relevant Chapters, OER 4 | Lecture, Discussion |
| 12 | X-Ray Diffraction | TB - Elements of X-Ray diffraction - B.D. Cullity, Relevant Chapters, OER 5 | Discussion |
| 13 | Solid State Physics Principles | RB - Principles of Solid State Physics - R. A. Levy, Relevant Chapters | Lecture, Demonstration |

| | | | |
|---|---|---|---|
| 14 | Review and Applications | TB - Solid State Physics- S.O. Pillai, Relevant Chapters | Practical Lab Session |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the fundamental principles and characteristics of various crystal systems in solid state physics. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Demonstrate proficiency in identifying and describing the structural arrangements of different crystal systems. | | |
| **3** | Apply theoretical knowledge to analyze and differentiate crystal structures in practical laboratory experiments. | | |
| **4** | Gain insights into the unique properties and applications of specific crystal systems, such as perovskites, in various scientific and technological contexts. | | |

## Semester V

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | SCPH301 | Quantum mechanics and applications | 4 |
| | SCPH303 | Digital Systems And Applications | 4 |
| 2 | SCPH351 | Digital Systems And Applications Lab | 1 |
| 3 | UNS106 | Synthesis of Nanomaterials-I | 4 |
| 4 | UNS107 | Synthesis of Nanomaterials-I lab | 1 |
| 5 | SCPH305 | Applied Optics | 4 |
| | SCPH307 | Laser Fundamentals | |
| 6 | SIPH002 | Evaluation of Summer Internship /Project | 2 |
| TOTAL | | | 20 |

| **SCPH301** | QUANTUM MECHANICS AND APPLICATIONS | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Quantum Mechanics | | | | |
| **Co-requisites** | Mathematical Physics | | | | |

**Course Objectives**

1. Acquire knowledge of time independent perturbed systems using Schrödinger's equation.
2. Know about the mechanism related to electronic transitions using time independent perturbed systems.
3. Explanation of physical significance of phenomenon of scattering quantum mechanically.
4. Deep insight about the co-relationship between relativity and quantum mechanics.

**Course Outcomes**

On completion of this course, the students will be able to

- CO1. Demonstrate a deep understanding of wave functions, Schrodinger's equation, and principles of quantum mechanics, enabling them to explain these concepts accurately.
- CO2. Apply the concepts of quantum mechanics to one-dimensional potentials, harmonic oscillators, and hydrogen-like atoms.

- CO3. Analyze quantum phenomena; students will interpret the behavior of atoms in electric and magnetic fields, demonstrating their understanding of space quantization and the Zeeman effect.
- CO4. Synthesize knowledge on many electron atoms, spin orbit coupling, and Hund's Rule, to solve complex quantum problems and interpret atomic states.

**Catalog Description**

This course is intended to cover most of the basic topics in quantum mechanics, related to perturbed system. This course gives the theoretical explanations of perturbed systems (time independent and time dependent both) and co-relates the experimental data to theoretical aspects. Here the scattering problem tackled by quantum mechanically. Moreover, the course bridges different branches of physics, like spectroscopy, relativity etc, to quantum mechanics

**Course Content**

**Unit 1: 20 Contact Hours**

**Wave Function and Schrodinger equation:** Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. (6 Lectures)

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension: wave packets, momentum space wavefunction (qualitative discussion); Position-momentum uncertainty principle. (10 Lectures)

**Unit 2: 10 Contact Hours**

**General discussion of bound states in an arbitrary potential**- continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions; Hermite polynomials; ground state, zero point energy & uncertainty principle. (12 Lectures)

**Unit 3: 10 Contact Hours**

**Quantum theory of hydrogen-like atoms**: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions; shapes of the probability densities for ground & first excited states ; Orbital angular momentum quantum numbers l and m; s, p, d shells. (10 Lectures)

**Unit 4: 14 Contact Hours**

**Atoms in Electric & Magnetic Fields**: Space quantization- Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment, Stern- Gerlach Experiment. Zeeman Effect,

Gyromagnetic Ratio and Bohr Magneton. (8 Lectures)

Atoms in External Magnetic Fields:- Normal Zeeman Effect. Paschen Back (Qualitative Discussion only). (4 Lectures)

Many electron atoms: Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions, Fine structure. Spin orbit coupling-LS and JJ coupling. Spectral Notations for Atomic State- Term symbols, Total angular momentum, Vector Model, Hund's Rule.

(10 Lectures)

**Text books:**

1. Advanced Quantum Mechanics, Satya Prakesh, Kedarnaath Ramnaath (2016)
2. . Introduction to Quantum Mechanics, D.J Griffith, Prentice Hall (1994).

**Reference book(s):**

1. Modern Quantum Mechanics, J.J Sakurai, Revised Edition, 1994, Addision-Wesley.
2. Advanced Quantum Mechanics, B,S, Rajput, Pragati Prakashan (2004)
3. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
4. Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.
5. A Text book of Quantum Mechanics, P.M.Mathews& K.Venkatesan, 2nd Ed., 2010, McGraw Hill.

**Open Educational Resources (OER)**

1. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/
2. https://online.stanford.edu/courses/soe-ycphysics0002-quantum-mechanics
3. https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics
4. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/
5. https://ocw.uci.edu/courses/chem_131a_quantum_principles.html
6. https://openstax.org/details/books/university-physics-volume-3

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO10** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH301 Quantum mechanics and applications | CO1 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 3 | 2 | 2 | 2 |
| | CO2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 3 | 3 |
| | CO4 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Wave function and Schrodinger equation |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge about perturbed quantum mechanical systems and their applications |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | General discussion of bound states in an arbitrary potential |
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of relativistic quantum mechanical systems |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Quantum theory of hydrogen-like atoms |
| Local | - |
| Regional | - |
| National | - |
| Global | Physical significance of phenomenon of scattering quantum mechanically |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Atoms in electric & magnetic fields |
| Local | - |
| Regional | - |
| National | - |
| Global | Co-relationship between relativity and quantum mechanics |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |

| | |
|---|---|
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Use of software and simulations<br>Projects and group discussion |

## Teaching Plan:

| Week | Topics | Text/Reference Books/Open Education Resources | Teaching Learning Method |
|---|---|---|---|
| 1 | Introduction to Wave Function and Schrödinger equation | "Introduction to Quantum Mechanics" by D.J Griffith, https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/ | Lectures, guided readings |
| 2 | Properties of Wave Function, Expectation values | "Advanced Quantum Mechanics" by Satya Prakesh, https://online.stanford.edu/courses/soe-ycphysics0002-quantum-mechanics\ | Lectures, discussions |
| 3 | Eigenvalues and Eigenfunctions, Position, momentum, and Energy operators | "Quantum Mechanics: Theory and Applications" by Ajoy Ghatak, https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics | Lectures, problem-solving sessions |
| 4 | Time independent Schrödinger equation, Hamiltonian, stationary states | "Modern Quantum Mechanics" by J.J Sakurai. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/ | Lectures, practical sessions |
| 5 | Energy eigenvalues, wave packets, momentum space wavefunction | "Advanced Quantum Mechanics" by B,S, Rajput, MIT OpenCourseWare - https://ocw.mit.edu/index.htm | Lectures, problem-solving sessions |
| 6 | Bound states, square well potential, simple harmonic oscillator | "A Text book of Quantum Mechanics" by P.M.Mathews& K.Venkatesan, https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics | Lectures, discussions |
| 7 | Hermite polynomials, ground state, zero point energy | "Advanced Quantum Mechanics" by Satya Prakesh, https://ocw.uci.edu/courses/chem_131a_quantum_principles.html | Lectures, practical sessions |

| | | | |
|---|---|---|---|
| 8 | Quantum theory of hydrogen-like atoms | "Quantum Mechanics: Theory and Applications" by Ajoy Ghatak, https://openstax.org/details/books/university-physics-volume-3 | Lectures, problem-solving sessions |
| 9 | Angular momentum operator & quantum numbers | "Quantum Mechanics" by Eugene Merzbacher, https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics | Lectures, practical sessions |
| 10 | Radial wavefunctions, s, p, d shells | "Advanced Quantum Mechanics" by B,S, Rajput, https://online.stanford.edu/courses/soe-ycphysics0002-quantum-mechanics | Lectures, discussions |
| 11 | Atoms in Electric & Magnetic Fields, Space quantization | "Introduction to Quantum Mechanics" by D.J Griffith, https://openstax.org/details/books/university-physics-volume-3 | Lectures, problem-solving sessions |
| 12 | Spin Angular Momentum, Larmor's Theorem, Spin Magnetic Moment | "Quantum Mechanics" by Eugene Merzbacher, https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics | Lectures, practical sessions |
| 13 | Zeeman Effect, Normal Zeeman Effect | "Advanced Quantum Mechanics" by Satya Prakesh, https://online.stanford.edu/courses/soe-ycphysics0002-quantum-mechanics | Lectures, discussions |
| 14 | Many electron atoms, Pauli's Exclusion Principle, Fine structure | "A Text book of Quantum Mechanics" by P.M.Mathews& K.Venkatesan, https://www.khanacademy.org/science/physics/quantum-physics/quantum-numbers-and-orbitals/a/quantum-mechanics | Lectures, problem-solving sessions, course wrap-up |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Course Learning Outcomes (COs) | Teaching Learning Activity (TLA) | Assessment Task Methods (ATM) |
|---|---|---|---|
| 1 | Students will understand the principles of wave function, Schrödinger equation, and the basics of quantum mechanics. | Lectures, problem-solving sessions, discussions, and practical computer simulations. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| 2 | Students will apply quantum mechanics to bound states, potentials, and harmonic oscillators. | In-depth lectures, practical sessions, problem-solving tasks, and group discussions. | |
| 3 | Students will demonstrate knowledge of the quantum theory of hydrogen-like atoms and associated quantum numbers. | Theoretical lectures, practical sessions, group discussions, and computer simulations. | |
| 4 | Students will interpret the behavior of atoms in electric & magnetic fields and apply knowledge of many electron atoms. | Lectures, practical sessions, problem-solving tasks, and group discussions. | |

| | | | | | |
|---|---|---|---|---|---|
| **SCPH303** | DIGITAL SYSTEMS AND APPLICATIONS | L | T | P | C |
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Digital Electronics | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1 To acquire knowledge of Number system
2 Understanding the integrated and digital circuits
3 Better understanding of Boolean algebra and Data processing circuits
4 Better understanding of Flip flops ,registers and counter.

**Course Outcomes**

On completion of this course, the students will be able to

CO1. Recall various number systems and codes, demonstrating understanding in conversions and binary arithmetic operations.

CO2. Apply the principles of Boolean algebra in the simplification of logic circuits, employing methods like SOP, POS, and Karnaugh Map.

CO3. Design and analysis of combinational logic circuits, students will understand the operation of arithmetic building blocks, digital comparators, and multiplexers.

CO4. AnalyzE and designing sequential logic circuits, gaining knowledge in flip-flops, registers, and counters.

**Catalog Description**

This course is intended to cover most of the basic topics of digital electronics including Number systems, Logic gates and logic families,Boolean Algebra and Simplification, Arithmetic circuits, Data Processing Circuits, various Flip - flops , Clocks And Timers and Shift registers & counters. This course gives the circuit knowledge to students and students will be even able to start their startups. Course will also be beneficial for students in day to day life.

**Course Content**

**UNIT-I** **12 Contact Hours**

**Number systems** - decimal, binary, octal and hexadecimal systems - conversion from one number system to another. Codes - BCD code - Excess 3 code, Gray code ,Binary arithmetic - Binary addition - subtraction , 1's and 2's complement - Binary multiplication and division.

**UNIT-II** **15 Contact Hours**

**Boolean Algebra and Simplification Of Logic Circuits:**

Laws and theorems of Boolean algebra - De Morgan's theorems and their circuit implications - Duality theorem, simplification of Boolean equations – sum of products method (SOP), product of sums methods (POS ) Karnaugh map(K Map) - pairs, quads, octets - 2,3 and 4 variables ,Reduction of POS using K Map

**UNIT-III** **12 Contact Hours**

**Combinational Logic Circuits** : Arithmetic building blocks - Half adder - Full adder - parallel binary adder - Half subtractor - Full subtractor - The adder-subtractor - digital comparator - parity checker / generator , Multiplexers – Demultiplexers, Decoders

**UNIT-IV** **15 Contact Hours**

**Sequential Logic Circuits**

Flip - flops - RS Flip Flop - Clocked RS Flip-flop - D flip-flop - JK flip-flop - JK master slave flip-flop - T type flip-flop registers and counters: Types of registers - serial in serial out - serial in parallel out - parallel in serial out - parallel in parallel out - ring counter

**Text Books:**

1. **Malvino and Leech, Digital Principles and Application, 4th edition, Tata McGraw Hill, New Delhi**

Reference Books:

Millman and Halkias, Integrated Electronics, International edition, McGraw Hill, New Delhi

2. Thomas L. Floyd, Digital Fundamentals (Universal Book Stall, India).

**Open Educational Resources (OER)**

- https://cnx.org/contents/85c4b2c4-2b3b-4b73-b36a-3e76a9b8c506@1
- https://www.mathsisfun.com/binary-decimal-hexadecimal.html
- https://www.geeksforgeeks.org/digital-electronics-binary-coded-decimal/
- https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra
- https://www.youtube.com/playlist?list=PLBlnK6fEyqRhX6r2uhhlubuF5QextdCSM
- https://www.allaboutcircuits.com/textbook/digital/chpt-9/combinational-logic-functions/
- https://www.youtube.com/playlist?list=PLBlnK6fEyqRjMH3mWf6kwqiTbT798eAOm
- https://www.youtube.com/playlist?list=PLBlnK6fEyqRhFUZX8d6GwI5H5frkZT2lk

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code & Title** | **Course Outcome** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO10** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH303 | CO1 | 1 | 2 | | 2 | | 1 | | | | | 1 | 2 | | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIGITAL SYSTEMS AND APPLICATIONS | CO2 | | 2 | | 3 | | 2 | 2 | | | | | 3 | | 3 |
| | CO3 | | 1 | 2 | 3 | 3 | 2 | 1 | 1 | | | | 2 | 3 | 2 |
| | CO4 | | | 1 | 3 | 2 | 3 | 2 | 1 | | | | 3 | 2 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Number systems |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Basics of digital electronics |
| Employability | Design of analog to digital converter kits |
| Entrepreneurship | - |
| Skill development | Design of analog to digital converter kits |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Boolean algebra and simplification of logic circuits |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of digital logic circuits |
| Employability | Design of combinational circuits |
| Entrepreneurship | Design of analog to digital converter kits |
| Skill development | Design of combinational circuits |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Combinational logic circuits |
| Local | - |
| Regional | - |
| National | - |
| Global | Design of sequential circuits |
| Employability | Design of sequential circuits |
| Entrepreneurship | - |
| Skill development | Design of sequential circuits |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & | - |

| | |
|---|---|
| sustainability | |
| Unit iv | Sequential logic circuits |
| Local | - |
| Regional | - |
| National | - |
| Global | Applications of digital electronics |
| Employability | Design of memories<br>- |
| Entrepreneurship | - |
| Skill development | Design of memories<br>- |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Use of software and simulations<br>Projects and group discussion |

# Teaching Plan:

| Week | Topics | Reference Books / Open Education Resources | Teaching Learning Methods |
|---|---|---|---|
| 1 | Introduction to Number Systems | Malvino and Leech, Digital Principles and Application, https://cnx.org/contents/85c4b2c4-2b3b-4b73-b36a-3e76a9b8c506@1 | Lecture, Discussion, Q&A |
| 2 | Decimal, Binary, Octal, Hexadecimal | Malvino and Leech, Digital Principles and Application, https://cnx.org/contents/85c4b2c4-2b3b-4b73-b36a-3e76a9b8c506@1 | Lecture, Examples, Problem Solving |
| 3 | Conversion between Number Systems | Malvino and Leech, Digital Principles and Application, https://www.mathsisfun.com/binary-decimal-hexadecimal.html | Lecture, Demonstration, Exercises |
| 4 | BCD Code, Excess-3 Code, Gray Code | Malvino and Leech, Digital Principles and Application, https://www.mathsisfun.com/binary-decimal-hexadecimal.html | Lecture, Interactive Session |
| 5 | Binary Arithmetic - Addition, Subtraction | Malvino and Leech, Digital Principles and Application, https://www.geeksforgeeks.org/digital-electronics-binary-coded-decimal/ | Lecture, Examples, Practice Problems |
| 6 | 1's and 2's Complement, Binary Multiplication | Malvino and Leech, Digital Principles and Application, https://www.geeksforgeeks.org/digital-electronics-binary-coded-decimal/ | Lecture, Group Activities, Q&A |
| 7 | Binary Division, Review | Malvino and Leech, Digital Principles and Application, https://www.geeksforgeeks.org/digital-electronics-binary-coded-decimal/ | Lecture, Revision, Q&A |
| 8 | Boolean | Millman and Halkias, Integrated Electronics, | Lecture, |

| | | | |
|---|---|---|---|
| | Algebra - Introduction | https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra | Examples, Discussion |
| 9 | Boolean Laws and Theorems | Millman and Halkias, Integrated Electronics, https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra | Lecture, Problem Solving, Q&A |
| 10 | De Morgan's Theorems, Duality Theorem | Millman and Halkias, Integrated Electronics, https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra | Lecture, Group Activities, Q&A |
| 11 | Simplification of Boolean Equations | Thomas L. Floyd, Digital Fundamentals, https://www.khanacademy.org/computing/computer-science/algorithms/boolean-algebra | Lecture, Examples, Practice Problems |
| 12 | Karnaugh Map (K-Map) | Thomas L. Floyd, Digital Fundamentals, https://www.youtube.com/playlist?list=PLBlnK6fEyqRhFUZX8d6GwI5H5frkZT2lk | Lecture, Examples, Interactive Q&A |
| 13 | Combinational Logic Circuits | Thomas L. Floyd, Digital Fundamentals, https://www.youtube.com/playlist?list=PLBlnK6fEyqRhFUZX8d6GwI5H5frkZT2lk | Lecture, Lab Sessions, Q&A |
| 14 | Sequential Logic Circuits | Thomas L. Floyd, Digital Fundamentals, https://www.youtube.com/playlist?list=PLBlnK6fEyqRjMH3mWf6kwqiTbT798eAOm | Lecture, Examples, Review, Q&A |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Course Learning Outcomes (CLO) | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| I | Understand various number systems and their conversions. Acquire knowledge about different codes and binary arithmetic. | Lecture sessions explaining different number systems and their conversion. Interactive sessions on codes and binary arithmetic. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| II | Comprehend Boolean algebra and its laws. Apply Boolean algebra for the simplification of logic circuits. | Lecture and problem-solving sessions on Boolean algebra. Practical sessions on simplification of logic circuits using Boolean algebra. | |
| III | Understand the concepts of combinational logic circuits. Design and analyze various combinational logic circuits. | Lectures on combinational logic circuits theory. Lab sessions to experiment with design and analysis of these circuits. | |
| IV | Comprehend sequential logic circuits and flip-flops. Design and analyze various registers and counters. | Interactive lectures on sequential logic circuits. Lab sessions to implement flip-flops, registers and counters. | |

| SCPH351 | DIGITAL SYSTEMS AND APPLICATIONS LAB | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 30 | | | | |
| **Pre-requisites/Exposure** | Digital Electronics | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To acquire knowledge of Number system
2. Understanding the integrated and digital circuits
3. Better understanding of Boolean algebra and Data processing circuits
4. Better understanding of Flip flops, registers and counter.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Analyze and Comprehend digital logic gates, truth tables, flip flops, and counters, and be able to analyze their operations.

CO2: apply their knowledge of logic design to create various digital circuits, including adders, subtractors, shift registers, and counters.

CO3: Evaluate the validity of various digital circuits by verifying their truth tables and operational efficiency.

CO4: demonstrate hands-on skills in operating specific digital components such as TTL gates, multiplexers, demultiplexers, and digital counters.

**Catalog Description**

This course is intended to cover most of the basic topics of digital electronics including Number systems, Logic gates and logic families,Boolean Algebra and Simplification, Arithmetic circuits, Data Processing Circuits, various Flip - flops , Clocks And Timers and Shift registers & counters. This course gives the experimental and circuit knowledge to students which will be beneficial for students in day to day life.

**Course Content**

1. Verification of the truth tables of TTL gates.
2. Verify the NAND and NOR gates as universal logic gates.
3. Design and verification of the truth tables of Half and Full adder circuits.
4. Design and verification of the truth tables of Half and Full subtractor circuits.
5. Verification of the truth table of the Multiplexer 74150.
6. Verification of the truth table of the De-Multiplexer 74154.
7. Design and test of an S-R flip-flop using NOR/NAND gates.
8. Verify the truth table of a J-K flip-flop (7476)
9. Verify the truth table of a D flip-flop (7474)
10. Operate the counters 7490, 7493.
11. Design of 4-bit shift register (shift right).
12. Design of modulo-4 counter using J K flip flop..

.

**Reference Books:**


- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
- Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI


**Open Education Resources:**

- https://www.youtube.com/watch?v=47u7b2yh7s8&pp=ygUsdmVyaWZpY2F0aW9uIG9mIHRydXRoIHRhYmxlcyBvZiBsb2dpYyBnYXRlcyA%3D
- https://www.youtube.com/watch?v=lqN8xLTtdaA&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D
- https://www.youtube.com/watch?v=SYTDxdACf2E&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D
- https://www.youtube.com/watch?v=ap0RMkqHWHQ&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D
- https://www.youtube.com/watch?v=Ub1VixA-uSE&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D
- https://www.youtube.com/watch?v=q_W_qBnOZvw&pp=ygUxMTEuCURlc2lnbiBvZiA0LWJpdCBzaGlmdCByZWdpc3RlciAoc2hpZnQgcmlnaHQpLg%3D%3D
- https://www.youtube.com/watch?v=GJ8xxaIoIJ0&pp=ygUfT3BlcmF0ZSB0aGUgY291bnRlcnMgNzQ5MCwgNzQ5Mw%3D%3D
- https://www.youtube.com/watch?v=p6yPvw88BJk&pp=ygUhSW50cm9kdWN0aW9uIHRvIE11bHRpcGxleGVyIDc0MTUw
- https://www.youtube.com/watch?v=QKLWSs3z0C4&pp=ygUiUy1SIGZsaXAtZmxvcCB1c2luZyBOT1IvTkFORCBnYXRlcw%3D%3D
- https://www.youtube.com/watch?v=Ub1VixA-uSE&pp=ygUkTW9kdWxvLTQgY291bnRlciB1c2luZyBKIEsgZmxpcCBmbG9w

**Assessment & Evaluation**

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme and Course Mapping**

| Course Code & Title | Course Outcomes (COs) | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH351 Digital systems and applications lab | CO1 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 2 | 2 | 3 |
| | CO2 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 3 |
| | CO3 | 2 | 3 | 2 | 2 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 3 |
| | CO4 | 1 | 2 | 1 | 3 | 3 | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Digital systems and applications lab |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Experimental and circuit knowledge to students which will be beneficial for students in day to day life |
| Employability | Design of combinational and sequential circuits/ memories/ analog to digital converter kits |
| Entrepreneurship | Design of combinational and sequential circuits/ memories/ analog to digital converter kits |
| Skill development | Design of combinational and sequential circuits/ memories/ analog to digital converter kits |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4$^{th}$ IR | Hands on experience, use of software and simulations |

**Teaching Plan:**

| Weeks | Topic | Reference Books / Open Education Resources | Teaching Learning Method |
|---|---|---|---|
| 1 | Introduction to Digital Electronics | Modern Digital Electronics, R.P. Jain | Lectures, Tutorials |
| 2 | Basic Concepts of TTL gates | • Modern Digital Electronics, R.P. Jain https://www.youtube.com/watch?v=47u7b2yh7s8&pp=ygUsdmVyaWZpY2F0aW9uIG9mIHRydXRoIHRhYmxlcyBvZiBsb2dpYyBnYXRlcyA%3D | Lectures, Lab Work |
| 3 | Universal Logic Gates: NAND and NOR | • Modern Digital Electronics, R.P. Jain https://www.youtube.com/watch?v=lqN8xLTtdaA&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D | Lectures, Lab Work |
| 4 | Half and Full Adder Circuits | • Modern Digital Electronics, R.P. Jain https://www.youtube.com/watch?v=ap0RMkqHWHQ&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D | Lectures, Lab Work |
| 5 | Half and Full Subtractor Circuits | • Modern Digital Electronics, R.P. Jain https://www.youtube.com/watch?v=SYTDxdACf2E&pp=ygVeMy4JRGVzaWduIGFuZCB2ZXJpZmljYXRpb24gb2YgdGhlIHRydXRoIHRhYmxlcyBvZiBIYWxmIGFuZCBGdWxsIGFkZGVyIGFuZCBzdWJ0cmFjdG9yIGNpcmN1aXRzLg%3D%3D | Lectures, Lab Work |
| 6 | Introduction to Multiplexer 74150 | Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller https://www.youtube.com/watch?v=p6yPvw88BJk&pp=ygUhSW50cm9kdWN0aW9uIHRvIE11bHRpcGxleGVyIDc0MTUw | Lectures, Lab Work |
| 7 | Introduction to De-Multiplexer 74154 | Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller https://www.youtube.com/watch?v=p6yPvw88BJk&pp=ygUhSW50cm9kdWN0aW9uIHRvIE11bHRpcGxleGVyIDc0 | Lectures, Lab Work |

| | | | |
|---|---|---|---|
| | | MTUw | |
| 8 | S-R flip-flop using NOR/NAND gates | Microprocessor Architecture Programming and applications with 8085, R.S. Goankar https://www.youtube.com/watch?v=QKLWSs3z0C4&pp=ygUiUy1SIGZsaXAtZmxvcCB1c2luZyBOT1IvTkFORCBnYXRlcw%3D%3D | Lectures, Lab Work |
| 9 | J-K flip-flop (7476) | Microprocessor Architecture Programming and applications with 8085, R.S. Goankar<br>• https://www.youtube.com/watch?v=Ub1VixA-uSE&pp=ygU1My4JMTIuCURlc2lnbiBvZiBtb2R1bG8tNCBjb3VudGVyIHVzaW5nIEogSyBmbGlwIGZsb3A%3D | Lectures, Lab Work |
| 10 | D flip-flop (7474) | Microprocessor Architecture Programming and applications with 8085, R.S. Goankar | Lectures, Lab Work |
| 11 | Counters 7490, 7493 | Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa<br>• https://www.youtube.com/watch?v=GJ8xxaIoIJ0&pp=ygUfT3BlcmF0ZSB0aGUgY291bnRlcnMgNzQ5MCwgNzQ5Mw%3D%3D | Lectures, Lab Work |
| 12 | 4-bit shift register (shift right) | Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa<br>• https://www.youtube.com/watch?v=q_W_qBnOZvw&pp=ygUxMTEuCURlc2lnbiBvZiA0LWJpdCBzaGlmdCByZWdpc3RlciAoc2hpZnQgcmlnaHQpLg%3D%3D | Lectures, Lab Work |
| 13 | Modulo-4 counter using J K flip flop | Microprocessor 8085: Architecture, Programming and interfacing, A. Wadhwa https://www.youtube.com/watch?v=Ub1VixA-uSE&pp=ygUkTW9kdWxvLTQgY291bnRlciB1c2luZyBKIEsgZmxpcCBmbG9w | Lectures, Lab Work |

| | | | |
|---|---|---|---|
| 14 | Revision and Exam Preparation | All Books, Open Education Resources | Review Lectures, Problem-solving |

## Facilitating the Achievement of Course Learning Outcomes

| **Course Learning Outcomes (CLOs)** | **Teaching Learning Activity** | **Assessment Task Methods** |
|---|---|---|
| Understand the basic concepts of digital electronics and TTL gates. Comprehend the function and application of universal logic gates. Design and verify the operation of NAND and NOR gates. | Lectures, Tutorials, Lab Work | Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| Apply knowledge to design and verify half and full adder and subtractor circuits. | Lectures, Lab Work, Group Projects | |
| Understand and apply the principles of operation of multiplexers and de-multiplexers. | Lectures, Lab Work, Homework assignments | |
| Analyze the design and operation of S-R, J-K, D flip-flops and counters. Create a 4-bit shift register and a modulo-4 counter using J K flip flop. | Lectures, Lab Work, Group Projects | |

| | | | | | |
|---|---|---|---|---|---|
| **UNS106** | SYNTHESIS OF NANOMATERIALS-I | L | T | P | C |
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | | | | | |

**Course outcomes**

CO1: Describe the fundamental concepts and methods involved in nanotechnology, including top-down and bottom-up processes, the properties of atoms and solids, and the different classification of nanostructures.
CO2: Apply principles of nanotechnology to understand the synthesis and growth of nanoparticles through both homogeneous and heterogeneous nucleation.
CO3: Analyze various fabrication methods and their impact on the properties of nanoparticles and nanostructures.
CO4: Evaluate the effectiveness of various methods for creating one-dimensional nanostructures, such as nanowires and nanorods.

**UNIT- I** **20 contact hours**

**Generic methodologies for nanotechnology: classification and fabrication**

Introduction and classification: definition nanotechnology, Classification of nanostructures, Nanoscale architecture, Summary of the electronic properties of atoms and solids: The isolated atom Bonding between atoms, Giant molecular solids, The free electron model and energy bands, Crystalline solids, Periodicity of crystal lattices, Electronic conduction; Effects of the nanometer length scale: Changes to the system total energy, Changes to the system structure, How nanoscale dimensions affect properties, Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nanosystems, Preparation, safety and storage issues.

**UNIT-II** **10 contact hours**

**Physical Chemistry of Solid Surfaces**

Introduction, Surface Energy, Chemical Potential as a Function of Surface Curvature, Electrostatic Stabilization: Surface charge density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions.

**UNIT-III** **17 contact hours**

**Zero-Dimensional Nanostructures: Nanoparticles**

Introduction, Nanoparticles through Homogeneous Nucleation:Fundamentals of homogeneous nucleation, Subsequent growth of nuclei (Growth controlled by diffusion, Growth controlled by surface process), Synthesis of metallic nanoparticles(Influences of reduction reagents, Influences by other factors, Influences of polymer stabilizer), Synthesis of semiconductor nanoparticles, Synthesis of oxide nanoparticles (Introduction to sol-gel processing, Forced hydrolysis, Controlled release of ions),Vapor phase reactions, Solid state phase segregation;
Nanoparticles through Heterogeneous Nucleation:(Fundamentals of heterogeneous nucleation, Synthesis of nanoparticles); Kinetically Confined Synthesis of Nanoparticles:(Synthesis inside micelles or using microemulsions, Aerosol synthesis, Growth termination, Spray pyrolysis, Template-based synthesis);Epitaxial Core-Shell Nanoparticles.

**UNIT IV** **17 contact hours**

**One-Dimensional Nanostructures: Nanowires and Nanorods**

Introduction, Spontaneous Growth: Evaporation (dissolution)-condensation growth:(Fundamentals of evaporation (dissolution)-condensation growth, Evaporation-condensation growth, Dissolution-condensation growth);
Vapor (or solution)-liquid-solid (VLS or SLS) growth:(Fundamental aspects of VLS and SLS growth, VLS growth of various nanowires, Control of the size of nanowires, Precursors and catalysts, SLS growth);
Stress-induced recrystallization: Template-Based Synthesis: Electrochemical deposition, Electrophoretic deposition, Template filling (Colloidal dispersion filling, Melt and solution filling, Chemical vapor deposition, Deposition by centrifugation), Converting through chemical reactions; Electrospinning; Lithography.

Textbooks:

1. "Introduction to Nanoscience and Nanotechnology" by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore
2. "Nanoscale Science and Technology" by Robert Kelsall, Ian Hamley, Mark Geoghegan

Reference Books:

1. "Nanochemistry: A Chemical Approach to Nanomaterials" by Geoffrey A. Ozin, Andre Arsenault
2. "Nanotechnology: An Introduction" by Jeremy Ramsden
3. "The Physics of Nanoelectronics: Transport and Fluctuation Phenomena at Low Temperatures" by Tero T. Heikkila
4. "Nanoscale: Visualizing an Invisible World" by Kenneth S. Deffeyes, Stephen E. Deffeyes
5. "Nanotechnology: Principles and Practices" by Sulabha K. Kulkarni

**Open Educational Resources (OER)**

- **https://byjus.com/jee/surface-chemistry/**
- **https://onlinecourses.nptel.ac.in/noc21_cy45/preview**
- **https://www.youtube.com/watch?v=O2So0xcdDiA**
- **https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/**
- **https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and** | **Course Out** | **PO** | **PO** | **PO** | **PO4** | **PO** | **PO** | **PO7** | **PO** | **PO** | **PO1** | **PSO** | **PSO** | **PSO** | **PS** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| Title | come | 1 | 2 | 3 | | 5 | 6 | | 8 | 9 | 0 | 1 | 2 | 3 | O4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS106 SYNTHESIS OF NANOMATERIALS-I | CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| | CO2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Generic methodologies for nanotechnology: classification and fabrication |
|---|---|
| Local | Understanding basic concepts of nanotechnology at community colleges or local industries. |
| Regional | Sharing and collaboration among regional research institutes. |
| National | Establishing national standards & guidelines for nanotech. |
| Global | Collaborative international research & global standards for nanotech. |
| Employability | Creation of jobs in nanotech research & development. |
| Entrepreneurship | Start-ups offering nano-fabrication services. |
| Skill development | Training in nano-fabrication techniques. |
| Professional ethics | Responsible nanotech development & research practices. |
| Gender | Promote gender equality in nanotech research roles. |
| Human values | Ensuring nanotech is used for the betterment of society. |
| Environment & sustainability | Adopting sustainable nanotech fabrication practices. |
| Unit ii | Physical Chemistry of Solid Surfaces |
| Local | Enhancing knowledge of solid surfaces in local industries. |
| Regional | Regional workshops on surface chemistry. |
| National | National policies on solid surface treatments & applications. |
| Global | International collaborations on advanced surface chemistry research. |
| Employability | Jobs in surface analysis, research, and application development. |
| Entrepreneurship | Businesses offering specialized surface treatments & analytics. |
| Skill development | Skill development in surface analysis techniques. |
| Professional ethics | Ensuring ethical practices in surface treatment & analysis. |
| Gender | Encourage more female scientists in surface chemistry research. |
| Human values | Consideration of human values in the application of surface treatments. |
| Environment & sustainability | Environmentally friendly surface treatments and practices. |
| Unit iii | Zero-Dimensional Nanostructures: Nanoparticles |
| Local | Promotion of local manufacturing & research in nanoparticles. |
| Regional | Regional collaborations for nanoparticle manufacturing & research. |
| National | Development of national manufacturing hubs for nanoparticles. |
| Global | Sharing and collaboration on nanoparticle synthesis at an international level. |

| | |
|---|---|
| Employability | Employment opportunities in nanoparticle manufacturing industries. |
| Entrepreneurship | Start-ups focusing on the production and sale of nanoparticles for various applications. |
| Skill development | Training programs on nanoparticle synthesis methods. |
| Professional ethics | Adhering to ethical standards in nanoparticle production. |
| Gender | Promoting gender inclusivity in nanoparticle research and development. |
| Human values | Using nanoparticles for applications that benefit society at large. |
| Environment & sustainability | Sustainable methods of nanoparticle synthesis and minimizing environmental impacts. |
| Unit iv | One-Dimensional Nanostructures: Nanowires and Nanorods |
| Local | Local manufacturing & research in nanowires and nanorods. |
| Regional | Regional advancements in nanowire and nanorod production techniques. |
| National | National advancements in one-dimensional nanostructures for various applications. |
| Global | Global research partnerships in the field of nanowires and nanorods. |
| Employability | Employment in industries focusing on nanowires and nanorods. |
| Entrepreneurship | Entrepreneurial ventures into nanowire & nanorod production and applications. |
| Skill development | Workshops on the fabrication of nanowires and nanorods. |
| Professional ethics | Maintaining ethical standards in the manufacturing of nanowires and nanorods. |
| Gender | Gender equality in roles related to research and development of nanowires and nanorods. |
| Human values | Manufacturing nanowires & nanorods keeping human needs and values in mind. |
| Environment & sustainability | Emphasis on green and sustainable practices in the production of nanowires and nanorods. |
| SDG | Goal 9: Industry, Innovation, and Infrastructure, Goal 12: Responsible Consumption and Production Goal 6: Clean Water and Sanitation, Goal 14: Life Below Water , Goal 3: Good Health and Well-being, Goal 7: Affordable and Clean Energy, Goal 11: Sustainable Cities and Communities |
| Nep 2020 | Multidisciplinary Education Emphasis on Research and Innovation, Integrating Technology in Education, Focus on Experiential Learning, Emphasis on Practical Knowledge, Critical Thinking and Creativity |
| Poe/4$^{th}$ IR | Advanced Materials, Nanotechnology |

# Teaching Plan:

| Week | Topics | Reference Books/Open Education Resources | Teaching Learning Method |
|---|---|---|---|
| 1 | Introduction to nanotechnology, classification of nanostructures | "Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. , **https://byjus.com/jee/surface-chemistry/** Owens | Lecture, Group Discussion |
| 2 | Nanoscale architecture, electronic properties of atoms and solids | "Nanostructures and Nanotechnology" by Douglas Natelson, **https://onlinecourses.nptel.ac.in/noc21_cy45/preview** | Lecture, Group Discussion |
| 3 | The free electron model and energy bands, crystalline solids, periodicity of crystal lattices | "Nanostructures and Nanotechnology" by Douglas Natelson, **https://www.youtube.com/watch?v=O2So0xcdDiA** | Lecture, Group Discussion |
| 4 | Electronic conduction, effects of the | "Nanostructures and Nanotechnology" by Douglas | Lecture, Group Discussion |

| | | | |
|---|---|---|---|
| | nanometre length scale | Natelson, **https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/** | |
| 5 | Fabrication methods: Top-down processes, bottom-up processes | "Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. Owens, **https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508** | Lecture, Lab Session |
| 6 | Introduction to surface energy, chemical potential as a function of surface curvature | "Nano: The Essentials" by T. Pradeep, **https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/** | Lecture, Lab Session |
| 7 | Electrostatic Stabilization: Surface charge density, electric potential at the proximity of solid surface, Van der Waals attraction potential | "Nano: The Essentials" by T. Pradeep,, **https://www.youtube.com/watch?v=O2So0xcdDiA** | Lecture, Lab Session |
| 8 | Introduction to nanoparticles through homogeneous nucleation, subsequent growth of nuclei | "Nano: The Essentials" by T. Pradeep, **https://onlinecourses.nptel.ac.in/noc21_cy45/preview** | Lecture, Lab Session |
| 9 | Synthesis of metallic nanoparticles, semiconductor nanoparticles, oxide nanoparticles | "Principles of Nanotechnology" by G. Ali Mansoori, **https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508** | Lecture, Lab Session |
| 10 | Nanoparticles through Heterogeneous Nucleation, Kinetically Confined Synthesis of Nanoparticles | "Principles of Nanotechnology" by G. Ali Mansoori, **https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/** | Lecture, Lab Session |
| 11 | Introduction to one-dimensional nanostructures, spontaneous growth, evaporation (dissolution)-condensation growth | "Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, **https://www.youtube.com/watch?v=O2So0xcdDiA** | Lecture, Lab Session |
| 12 | Vapor (or solution)-liquid-solid (VLS or SLS) growth, stress-induced recrystallization | "Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, **https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508** | Lecture, Lab Session |

| | | | |
|---|---|---|---|
| 13 | Template-Based Synthesis: Electrochemical deposition, Electrophoretic deposition, Template filling | "Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, **https://www.youtube.com/watch?v=O2So0xcdDiA** | Lecture, Lab Session |
| 14 | Revision and assessment preparation | All reference books and resources | Group Discussion, Q&A |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| I | Understand the principles of nanotechnology, classification and fabrication of nanostructures, the effects of nanoscale dimensions on properties, and fabrication methods. | Lectures, group discussions, and problem-solving sessions. Students will study theoretical concepts and work on practical problems related to the fabrication of nanostructures. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| II | Gain knowledge about the physical chemistry of solid surfaces, including surface energy, chemical potential, electrostatic stabilization, and DLVO theory. | Lectures and lab experiments. Students will study theoretical concepts and apply them in laboratory experiments to better understand the physical chemistry of solid surfaces. | |
| III | Understand the concepts of zero-dimensional nanostructures, including the synthesis and growth of nanoparticles through homogeneous and heterogeneous nucleation, and kinetically confined synthesis. | Lectures, lab experiments, and group projects. Students will study theoretical concepts, conduct experiments, and work on projects related to the synthesis and growth of nanoparticles. | |
| IV | Learn about one-dimensional nanostructures, the growth processes of nanowires and nanorods, stress-induced recrystallization, and template-based synthesis techniques. | Lectures, lab experiments, and problem-solving sessions. Students will study theoretical concepts and conduct experiments related to the growth processes of nanowires and nanorods. | |

| **UNS107** | **SYNTHESIS OF NANOMATERIALS-I Lab** | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 26 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.

3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

**Course Outcomes:**

**CO1** Students will be able to explain the principles of film growth and differentiate between various deposition techniques, such as solid state reaction method, coprecipitation method, and sol-gel films.

**CO2** Students will comprehend the properties and applications of magneticl nanomaterials.

**CO3** Students will comprehend the properties and applications of dielectric nanomaterials.

**CO4** Students will be able to identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.

**CATALOG DESCRIPTION**

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

**Course Content**

1, Stabilization of BaTiO3 particles..
2. Preparation of silver wires.
3. Preparation of magnetite/PS composite,
4 Find the dielectric properties of multilayer composite material.
5. Prepare core-shell type nanoparticles..
6 Find the optical band gap of BaTiO3 nanoparticles.
7. Study the effect of heating rate during calcination on the optical properties of BaTiO3.
8. Find the X ray density of nanoparticles.

**Suggested Text Books**

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

**Advanced Readings:**

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

**Open Educational Resources (OER)**

https://www.youtube.com/watch?v=DnozInAi1q0
https://pubs.acs.org/doi/10.1021/acs.inorgchem.8b00381
https://pubs.rsc.org/en/content/articlelanding/2018/nr/c8nr02242a
https://pubs.acs.org/doi/10.1021/acs.nanolett.0c01565
https://doi.org/10.1007/s13233-017-5065-1

https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=853840
https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202102221
https://pubs.acs.org/doi/abs/10.1021/cr100449n
https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00343a
https://www.mdpi.com/2073-4360/14/21/4664

**Assessment & Evaluation**

| **Components** | **Conduct of Experiment** | **Lab Record/Viva Voce** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Objectives (CO)** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO 2** | **PSO 3** | **PSO4** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1: Principles of film growth | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | | 1 | 1 |
| CO2: Properties and applications | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | | 1 | 1 |
| CO3: Practical skills in lithography | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | | 1 | 1 |
| CO4: Identify real-world applications | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | | 1 | 1 |

(Note: The numbers 1, 2, and 3 represent "lightly mapped," "moderately mapped," and "strongly mapped," respectively. Higher numbers indicate a stronger mapping between the Course Objectives and the Program Outcomes/Program Specific Outcomes.)

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit | Course content |
|---|---|
| Local | Strengthening local materials and electronics sector with advanced nanotech methodologies. |
| Regional | Enhancing regional research and industries with material innovation, fostering tech-based development. |
| National | Contributing to national advancements in electronics, materials science, and research sectors. |
| Global | Aligning with global research trends, fostering international collaborations, and integrating into global electronics and materials markets. |
| Employability | Opening avenues in electronics, material science, R&D roles, and nano-technology industries. |
| Entrepreneurship | Empowering tech-driven startups in nanomaterial production, electronics, and advanced material applications. |
| Skill development | Imparting crucial skills in nanomaterial preparation, analysis, and research |

| | |
|---|---|
| | methodologies. |
| Professional ethics | Advocating for responsible research practices, ethical material sourcing, and safe laboratory protocols. |
| Gender | Encouraging inclusivity in the traditionally male-dominated fields of material science and research. |
| Human values | Emphasizing on the responsible use of knowledge for societal benefits and ethical considerations in research. |
| Environment & sustainability | Promoting green practices in material synthesis, emphasizing eco-friendly methodologies and waste reduction. |
| SDG | Aligning with goals like Industry, Innovation, Infrastructure (Goal 9), and Responsible Consumption and Production (Goal 12) for sustainable development. |
| Nep 2020 | Reinforcing the emphasis on practical knowledge, critical thinking, and integration of tech in education as per India's National Education Policy. |
| Poe/4th IR | Preparing for the Fourth Industrial Revolution by equipping learners with skills in advanced materials, nanotechnology, and innovative research practices vital for the age of cyber-physical systems. |

# Teaching Plan

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| **Week 1** | | | Class test/presentation/Assignments/Quizzer/ Viva/Project Class test/presentation/Assignments/Quizzer/ Viva/Project |
| **Week 2** | Stabilization of BaTiO3 particles.. | https://www.youtube.com/watch?v=DnozInAi1q0 https://pubs.acs.org/doi/10.1021/acs.inorgchem.8b00381 | |
| **Week 3** | Preparation of silver wires. | https://pubs.rsc.org/en/content/articlelanding/2018/nr/c8nr02242a<br><br>https://pubs.acs.org/doi/10.1021/acs.nanolett.0c01565 | |
| **Week 4** | Preparation of magnetite/PS composite, | https://doi.org/10.1007/s13233-017-5065-1 | |
| **Week 5** | Find the dielectric properties of multilayer composite material. | https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=853840<br><br>https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202102221 | |
| **Week 6** | Prepare core-shell type nanoparticles.. | https://pubs.acs.org/doi/abs/10.1021/cr100449n<br><br>https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00343a | |

| | | | |
|---|---|---|---|
| **Week 7** | Find the optical band gap of BaTiO3 nanoparticles. | https://www.mdpi.com/2073-4360/14/21/4664 | |
| **Week 8** | Study the effect of heating rate during calcination on the optical properties of BaTiO3. | https://doi.org/10.1007/s11082-022-04516-8 | |
| **Week 9** | Study the effect of heating rate during calcination on the optical properties of BaTiO3. | https://doi.org/10.1007/s11082-022-04516-8 | |
| **Week 10** | Find the X ray density of nanoparticles. | https://www.mdpi.com/2073-4360/14/21/4664 | |
| **Week 11** | Data analysis and interpretation for all experiments. | | |
| **Week 12** | Finalize reports and presentations for each experiment. | | |
| **Week 13** | Review, discussion, and presentation of experimental findings. | | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Explain the principles of film growth and differentiate between various deposition techniques, such as solid state reaction method, coprecipitation method, and sol-gel films. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations, quizzers and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Comprehend the properties and applications of magnetic nanomaterials. | | |
| **3** | Comprehend the properties and applications of dielectric nanomaterials. | | |
| **4** | Identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices. | | |

| SCPH305 | Applied Optics | L | T | P | C |
|---|---|---|---|---|---|
| Version 1.0 | | 4 | 0 | 0 | 4 |
| Total Contact Hours | 54 | | | | |
| Pre-requisites/Exposure | Waves and Optics | | | | |
| Co-requisites | Electromagnetic Theory | | | | |

**Course Objectives**

1. To prepare the students to have basic ideas in.Applied Optics.
2. To introduce advance level experiments in the area of Fourier Optics, Fibre Optics, Lasers and holography.
3. To understand the working mechanism of various Laser systems and detectors.
4. To acquire knowledge of application areas of Fourier Optics and Fibre Optics.

**Course Outcomes**

On completion of this course, the students will be able to

CO1: Recall the principles of lasers, spontaneous and stimulated emissions, Einstein's coefficients, and the theory of laser action.
CO2: Apply the knowledge gained in conducting a variety of experiments involving lasers, semiconductor sources and detectors, Fourier optics, holography, and fiber optics.
CO3: Analyze the results obtained from different experiments to interpret their meaning in the broader context of laser technology and photonics.
CO4: Evaluate the effectiveness of different types of lasers and optical technologies in specific applications, and devise experiments to test the performance and properties of these technologies.

**Catalog Description**

This laboratory introduces the students to advanced level experiments in optics in the area of Fourier Optics, Lasers and detectors, Fibre Optics and Holography. Students are also exposed to optical sources, detector and measurement of various physical parameters using optical techniques.

**Course Content**

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

**Unit I Sources and Detectors** **15 Contact Hours**

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

**Experiments on Lasers:**

a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser

**Experiments on Semiconductor Sources and Detectors:**

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor

**Unit II Fourier Optics** **14 Contact Hours**

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

**Experiments on Fourier Optics:**
a. Fourier optic and image processing
1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system
b. Fourier Transform Spectroscopy
Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.
**Experiment:**
To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

**Unit III Holography** **10 Contact Hours**
Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition
**Experiments on Holography and interferometry:**
1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

**Unit IV Photonics: Fibre Optics** **15 Contact Hours**
Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating
**Experiments on Photonics: Fibre Optics**
a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre
c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre.

**Text Books:**
- "Introduction to Optical Electronics" by Amnon Yariv and Pochi Yeh.
- "Principles of Lasers" by Orazio Svelto.
- "Introduction to Fourier Optics" by Joseph W. Goodman.

**Reference Books:**
- Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.
- LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
- Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
- Nonlinear Optics, Robert W. Boyd, (Chapter-I), 2008, Elsevier.
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optical Systems and Processes, Joseph Shamir, 2009, PHI Learning Pvt. Ltd.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.
- Optical Physics, A.Lipson, S.G.Lipson, H.Lipson, 4th Edn., 1996, Cambridge Univ. Press

**Open Educational Resources (OER)**

- MIT OpenCourseWare - Introduction to Applied OpticsLearnOptics
- Coursera - Introduction to Lasers
- edX - Practical Deep Learning for Coders
- Stanford Online - Holography and Lasers
- https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/v/polarization-of-light-linear-and-circular
- https://sciencecready.com.au/pages/diffraction
- NPTEL Online Certification Course - Optical Fiber Communication
- Educational YouTube videos
- https://www.youtube.com/watch?v=3FIGyj0ioPA
- https://www.youtube.com/watch?v=OD7DiQ0SuJI
- https://www.spiedigitallibrary.org/conference-proceedings-of-spie/0/PC120050/Meta-optics-for-image-processing/10.1117/12.2609817.full

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code & Title** | **Course Outcome** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO10** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH305 Applied | CO1 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Optics | CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Sources and detectors |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of working of lasers and detectors |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Fourier optics give |
| Local | - |
| Regional | - |
| National | - |
| Global | Applications of fourier optics |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Holography |
| Local | - |
| Regional | - |
| National | - |
| Global | Applications of holography in real world |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Photonics: fibre optics |
| Local | - |
| Regional | - |

| | |
|---|---|
| National | - |
| Global | Fundamentals of fibre optics |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | (skills for decent work, safe and inclusive learning environments) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Hands on experience, projects and group discussion |

**Teaching Plan:**

| **Week** | **Topics** | **Reference Books/Open Education Resources** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Introduction to Lasers | LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, MIT OpenCourseWare - Introduction to Applied Optics | Lecture, Reading |
| 2 | Spontaneous and Stimulated Emissions, Theory of Laser Action | LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, Coursera - Introduction to Lasers: | Lecture, Reading |
| 3 | Einstein's Coefficients, Light Amplification | Fundamental of Optics, F. A. Jenkins & H. E. White, Coursera - Introduction to Lasers: | Lecture, Reading |
| 4 | Characterization of Laser Beam, He-Ne laser | Optics, Karl Dieter Moller, Learning by computing with model examples Coursera - Introduction to Lasers: | Lecture, Demonstration |

| | | | |
|---|---|---|---|
| 5 | Semiconductor Lasers, Determination of the Grating Radial Spacing of the CD | Optoelectronic Devices and Systems, S.C. Gupta, MIT OpenCourseWare - Introduction to Applied Optics | Lecture, Laboratory |
| 6 | Width of the Wire or Slit Using Diffraction Pattern | Optics, Karl Dieter Moller, Learning by computing with model examples, https://sciencecready.com.au/pages/diffraction | Lecture, Laboratory |
| 7 | Polarization Angle of Laser Light, Thermal Expansion of Quartz | Optoelectronic Devices and Systems, S.C. Gupta, https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/v/polarization-of-light-linear-and-circular | Lecture, Laboratory |
| 8 | V-I Characteristics of LED, Study the Characteristics of Solid State Laser | Fibre Optics through Experiments, M.R.Shenoy, S.K.Khijwania, et.al., https://www.youtube.com/watch?v=OD7DiQ0SuJI | Lecture, Laboratory |
| 9 | Study the Characteristics of LDR, Photovoltaic Cell, Characteristics of IR Sensor | Optics, Karl Dieter Moller, Learning by computing with model examples, https://www.youtube.com/watch?v=3FIGyj0ioPA | Lecture, Laboratory |
| 10 | Spatial Frequency Filtering, Fourier Transforming Property of a Thin Lens | Nonlinear Optics, Robert W. Boyd, (Chapter-I), V https://ocw.mit.edu/courses/2-71-optics-spring-2009/resources/lecture-18-spatial-filtering-lens-transfer-functions-transforms/ | Lecture, Reading |

| | | | |
|---|---|---|---|
| 11 | Optical Image Addition/Subtraction, Optical Image Differentiation | Optics, Karl Dieter Moller, Learning by computing with model examples, https://www.spiedigitallibrary.org/conference-proceedings-of-spie/0/PC120050/Meta-optics-for-image-processing/10.1117/12.2609817.full | Lecture, Laboratory |
| 12 | Fourier Optical Filtering, Construction of an Optical 4f System, Fourier Transform Spectroscopy | Nonlinear Optics, Robert W. Boyd, (Chapter-I) Educational YouTube videos: | Lecture, Laboratory |
| 13 | Basic Principle and Theory of Holography, Types of Holograms, White Light Reflection Hologram | Optical Physics, A.Lipson, S.G.Lipson, H.Lipson Educational YouTube videos: | Lecture, Reading |
| 14 | Optical Fibres and Their Properties, Principle of Light Propagation through a Fibre, Numerical Aperture | Fibre Optics through Experiments, M.R.Shenoy, S.K.Khijwania, et.al., NPTEL Online Certification Course - Optical Fiber Communication | Lecture, Laboratory |

**Facilitating the Achievement of Course Learning Outcomes**

| **Unit** | **Course Learning Outcomes** | **Teaching-Learning Activities** | **Assessment Task Methods** |
|---|---|---|---|
| I | Understand the basic principles and working of lasers and detectors. Perform various | Lectures on laser principles, demonstrations of He-Ne and semiconductor lasers. Lab sessions to | • Presentations and class discussions. • Assignments and class |

| | | | |
|---|---|---|---|
| | experiments with lasers, including diffraction patterns and grating radial spacing. | conduct experiments. | tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| II | Understand the concept of spatial frequency filtering and Fourier transforming property of a thin lens. | Lectures on Fourier optics and Fourier Transform Spectroscopy. Lab sessions to conduct experiments. | |
| III | Understand the principles and applications of holography. | Lectures on holography and different types of holograms. Lab sessions to conduct experiments. | |
| IV | Understand the principles and properties of optical fibers. Understand the principle of light propagation through a fiber and the concept of numerical aperture. | Lectures on photonics and fiber optics. Lab sessions to conduct experiments. | |

| **SCPH307** | Laser Fundamentals | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Waves and Optics | | | | |
| **Co-requisites** | Electromagnetic Theory | | | | |

**Course Outcomes**

CO1: Recall and explain fundamental concepts related to lasers, including population inversion, the nature of electromagnetic radiation, absorption, and emission.

CO2: Apply their understanding of laser fundamentals and types to describe and analyze the effects of various types of lasers in different mediums (e.g., solid state, gaseous).

CO3: Compare and contrast different types of lasers (e.g., He-Ne laser, CO2 laser, Argon laser, Nd:YAG, Excimer laser, Diode laser, Fiber laser etc.) based on their characteristics.

CO4: Evaluate the appropriateness of specific laser types for various industrial applications, including measurements and material processing.

**Course Content**

**Unit I** **12 Contact Hours**

**Laser Fundamentals**

Phenomenon of population inversion. The Nature of Electromagnetic Radiation. Interaction of Electromagnetic Radiation with Matter. Absorption and Emission of Radiation by atoms, ions and molecules.

**Unit II** **12 Contact Hours**

**Types of lasers**

Laser medium (solid state medium: srystals, glass, semiconductor, gaseous medium). Types of lasers: He-Ne laser, CO2 laser, Argon laser, Nd:YAG, Excimer laser, Diode laser, Fiber laser etc.

**Unit III** **18 Contact Hours**

Optical parametric oscillator (OPO), Laser Electronics. Laser Beam Characteristics, Wavelength, Coherence, Mode and Beam Diameter, Polarisation. Laser Material Processing e.g. machining, welding, sintering, forming etc. Laser Fracture & Damage. Laser Communication

**Unit IV**

**INDUSTRIAL APPLICATION OF LASERS:** **12 Contact Hours**

Laser for measurement of distance, length, velocity, acceleration, current, voltage and Atmospheric effect – Material processing – Laser heating, welding, melting and trimming of material – Removal and vaporization

**Textbooks:**

1. "Lasers: Principles and Applications" by K. R. Nambiar. It provides a comprehensive understanding of the fundamentals of lasers, types of lasers, and their applications.
2. "Laser Electronics" by Joseph T. Verdeyen. It covers a wide range of topics including laser fundamentals, laser electronics, and laser beam characteristics.
3. "Laser Systems and Applications" by B.B. Laud. It gives a detailed view of laser applications in various fields, particularly in the industrial context.

**Reference Books:**

1. "Fundamentals of Photonics" by Bahaa E. A. Saleh and Malvin Carl Teich. A comprehensive guide that touches on many aspects of photonics, including lasers.
2. "Laser Fundamentals" by William T. Silfvast. This book provides an in-depth understanding of laser fundamentals.
3. "Introduction to Laser Technology" by C. Breck Hitz, J. J. Ewing, and Jeff Hecht. A book focused on laser technology and its diverse applications.
4. "Handbook of Laser Technology and Applications" by Colin Webb and Julian Jones. This handbook provides a comprehensive overview of lasers and their broad applications.

**Open Educational Resources:**

1. MIT OpenCourseWare - Introduction to Lasers
2. Introduction to Lasers - Stanford University
3. Laser Basics - Khan Academy
4. RP Photonics Encyclopedia
5. Photonics Media
6. Optical Society (OSA) - Webinar series on Lasers
7. Physics of Lasers - University of Southampton

8. Nobel Prize in Physics 1964 - Presentation Speech
9. Coursera - Introduction to Lasers
10. Laser Classroom - Lesson Plans

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO10** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH307 Laser Fundamentals | CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| | CO2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**Teaching Plan:**

| **Week** | **Topics** | **Reference Books/Open Education Resources** | **Teaching-Learning Method** |
|---|---|---|---|
| 1 | Introduction to Lasers, Phenomenon of Population Inversion | "Lasers: Principles and Applications" by K. R. Nambiar, MIT OpenCourseWare - Introduction to Lasers | Lecture, Reading |
| 2 | Nature of Electromagnetic Radiation | "Laser Electronics" by Joseph T. Verdeyen, Introduction to Lasers - Stanford University | Lecture, Reading |
| 3 | Interaction of Electromagnetic Radiation with Matter | "Lasers: Principles and Applications" by K. R. Nambiar, Laser Basics - Khan Academy | Lecture, Reading |
| 4 | Absorption and Emission of Radiation by Atoms, Ions, and | "Laser Fundamentals" by William T. Silfvast, RP Photonics Encyclopedia | Lecture, Reading |

| | | | |
|---|---|---|---|
| | Molecules | | |
| 5 | Types of Lasers: He-Ne Laser, CO2 Laser, Argon Laser, etc. | "Laser Systems and Applications" by B.B. Laud, Photonics Media | Lecture, Demonstration |
| 6 | More Types of Lasers: Nd:YAG, Excimer Laser, Diode Laser, Fiber Laser | "Handbook of Laser Technology and Applications" by Colin Webb and Julian Jones, Optical Society (OSA) - Webinar series on Lasers | Lecture, Demonstration |
| 7 | Laser Medium: Solid State Medium (Crystals, Glass, Semiconductor, Gaseous Medium) | "Introduction to Laser Technology" by C. Breck Hitz, J. J. Ewing, and Jeff Hecht, Physics of Lasers - University of Southampton | Lecture, Reading |
| 8 | Optical Parametric Oscillator (OPO), Laser Electronics | "Laser Electronics" by Joseph T. Verdeyen, Coursera - Introduction to Lasers | Lecture, Reading |
| 9 | Laser Beam Characteristics: Wavelength, Coherence, Mode, Beam Diameter, Polarisation | "Lasers: Principles and Applications" by K. R. Nambiar, Laser Classroom - Lesson Plans | Lecture, Demonstration |
| 10 | Laser Material Processing: Machining, Welding, Sintering, Forming, etc. | "Laser Systems and Applications" by B.B. Laud, Photonics Media | Lecture, Demonstration |
| 11 | Laser Fracture & Damage, Laser Communication | "Introduction to Laser Technology" by C. Breck Hitz, J. J. Ewing, and Jeff Hecht, Physics of Lasers - University of Southampton | Lecture, Reading |
| 12 | Industrial Applications of Lasers: Measurements | "Laser Systems and Applications" by B.B. Laud, MIT OpenCourseWare - Introduction to Lasers | Lecture, Demonstration |
| 13 | Industrial Applications of Lasers: Material Processing | "Handbook of Laser Technology and Applications" by Colin Webb and Julian Jones, Photonics Media | Lecture, Demonstration |
| 14 | Industrial Applications of Lasers: Laser Heating, Welding, Melting, Trimming, Removal and Vaporization | "Laser Systems and Applications" by B.B. Laud, Coursera - Introduction to Lasers | Lecture, Demonstration |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit | Course Learning Outcomes | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| I | Understand the phenomenon of population inversion, nature of electromagnetic radiation, absorption and emission of radiation by atoms, ions, and molecules. | Lectures on the fundamentals of lasers, group discussions, independent study, problem-solving exercises. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. |
| II | Learn about various types of lasers including He-Ne, CO2, Argon, Nd:YAG, Excimer, Diode, and Fiber lasers. | Lectures on different types of lasers, laboratory demonstrations, group discussions. | |
| III | Understand the concept of Optical | Lectures on OPO and laser | |

| | | | |
|---|---|---|---|
| | Parametric Oscillator (OPO), laser beam characteristics. | electronics, laboratory demonstrations, group discussions, independent study. | • End-term examinations. |
| IV | Understand how lasers can be used for various industrial applications, measurements and material processing. | Lectures on industrial applications of lasers, guest lectures from industry experts, case studies, group discussions. | |

## Semester VI

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH302 | Analog Systems and Applications | 4 |
| 2 | SCPH352 | Analog Systems and Applications Lab | 1 |
| 3 | SCPH304 | Themodynamics and Statistical Mechanics | 4 |
| 4 | SCPH306 | Electromagnetic theory | 4 |
| 5 | UNS108 | Characterisation techniques of nanomaterials | 4 |
| 6 | UNS109 | Characterisation techniques of nanomaterials Lab | 1 |
| 7 | | Select one course from a basket of course | 2 |
| 8 | SEC018 | Electrical circuits and network skills | 2 |
| TOTAL | | | 22 |

| SCPH302 | Analog Systems And Applications | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basics of Physics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

- Characteristics and working of pn junction.
- Two terminal devices: Rectifier diodes, Zener diode, photodiode etc
- NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.
- CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.
- Designing of different types of oscillators and their stabilities.
- Ideal and practical op-amps: Characteristics and applications.
- In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, oscillators and DACs. Also different applications using Op-Amp will be designed.

**Course Outcomes**

On completion of this course, the students will be able to

CO1 Understand the energy level diagram and conductivity of P and N type semiconductors.
CO2 Analyze PN junction diode behavior in forward and reverse biased modes.
CO3 Evaluate the characteristics and applications of two-terminal devices (e.g., rectifier diode, Zener diode, LEDs, photodiode, and solar cell).
CO4 Comprehend the working principles of bipolar junction transistors, their configurations, and amplifier circuits.

**Catalog Description**

This course designed to introduces the introductory concepts of semiconductor. The structure of course is planned to impart the functional knowledge of semiconductors to the device applications of semiconductors. The course includes the application of individual semiconductor part and the complex circuits of various component includes Integrated circuits. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

**Course Content**

**Unit I: 14 Lecture hours**

**Semiconductor Diodes**: P and N type semiconductors. Energy Level Diagram.Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanismin Forward and Reverse Biased Diode.

**Two-terminal Devices and their Applications**: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

**Unit II: 14 Lecture hours**

**Bipolar Junction transistors**: n-p-n and p-n-p Transistors. Characteristics of CB, CEand CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

**Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and VoltageDivider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of

Class A, B & C Amplifiers.
**Coupled Amplifier**: Two stage RC-coupled amplifier and its frequency response.

**Unit III:** **13 Lecture hours**

**Feedback in Amplifiers**: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.
**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

**Unit IV:** **13 Lecture hours**

**Operational Amplifiers (Black Box approach):** Characteristics of an Ideal andPractical OpAmp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.
**Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3)Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossingdetector (8) Wein bridge oscillator.
**Conversion:** Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)

**Text Books**
TB1. Robert Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 8Th Edition, Pearson Education, India.
TB2. Albert P. Malvino, David J. Bates. Electronic Principles, Eighth Edition, McGraw-Hill Education, United States.

**Reference Books/Materials**
RB1. Electronic Communication, Rudy and Cohlen (Prentice Hall).
RB2. Semiconductor Devices Physics & Technology by S. M. Sze (John Wiley).

**Open Educational Resources (OER)**

https://www.electronics-tutorials.ws/
**https://nptel.ac.in/courses/108102112**
**https://nptel.ac.in/courses/108105158**
**https://www.learningelectronics.net/**
**https://www.youtube.com/watch?v=XG3cVoUh7wc&list=PLs5_Rtf2P2r674CTMNJ3odeHk9Wtb-WWl**
**https://www.youtube.com/watch?v=EdUAecpYVWQ&list=PLwjK_iyK4LLBVM18VZ7JKW-q88FAtnr8_**

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH302 / Analog Systems And Applications | **CO1** | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 | 2 |
| | **CO2** | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | **CO3** | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | **CO4** | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |

1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Semiconductor diodes, two-terminal devices and their applications |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge about semiconductor devices |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Bipolar junction transistors and amplifiers |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of two terminal devices like Zener diode, photodiodes etc. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Feedback in amplifiers |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge about bipolar junction transistor |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |

| | |
|---|---|
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Operational amplifiers |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge about amplifiers |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4th IR | Use of software and simulations<br>Projects, hands on experience, internship, group discussion |

# Teaching Plan:

| **Weekly Teaching Plan** | Topic/Unit No. | Textbook / Reference Book / OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | Introduction to Semiconductor Diodes | TB 1 | Lecture, Discussion |
| 2 | PN Junction Diode and its Characteristics | TB 1 | Lecture, Practical |
| 3 | Diode Applications: Rectifiers and Zener Diode | TB 1 | Lecture, Practical |
| 4 | Light Emitting Diodes (LEDs) and Photodiodes | TB 1 | Lecture, Practical |
| 5 | Solar Cells and Bipolar Junction Transistors (BJTs) | TB 1 | Lecture, Practical |
| 6 | BJT Characteristics and Load Line Analysis | TB 2 | Lecture, Discussion |
| 7 | Transistor Biasing and | TB 2 | Lecture, Practical |

| | | | |
|---|---|---|---|
| | Stabilization Circuits | | |
| 8 | Transistor Amplifiers: CE Configuration | TB 2 | Lecture, Discussion |
| 9 | Transistor Amplifiers: CC and CB Configurations | TB 2 | Lecture, Practical |
| 10 | Amplifier Classification and Coupled Amplifiers | TB 2 | Lecture, Practical |
| 11 | Feedback in Amplifiers and Sinusoidal Oscillators | **https://www.learningelectronics.net/** | Lecture, Discussion |
| 12 | Barkhausen's Criterion and RC Phase-shift Oscillator | **https://nptel.ac.in/courses/108105158** | Lecture, Practical |
| 13 | Introduction to Operational Amplifiers (Op-Amps) | **https://nptel.ac.in/courses/108105158** | Lecture, Discussion |
| 14 | Op-Amp Applications and Analog-to-Digital Conversion (ADC) | https://www.youtube.com/watch?v=EdUAecpYVWQ&list=PLwjK_iyK4LLBVM18VZ7JKW-q88FAtnr8 | Lecture, Practical |

## Facilitating the Achievement of Course Learning Outcomes

| **Unit No.** | **Course Learning Outcomes (CLO)** | **Teaching-Learning Activity** | **Assessment Task Methods** |
|---|---|---|---|
| Unit I | Understand the principles of semiconductor diodes and their applications. | Lecture, Discussion, Practical | • Presentations and class discussions. • Assignments and class |

| | | | |
|---|---|---|---|
| | Analyze the behavior of PN junction diodes in various biasing conditions. | | tests. • Student presentations. • Mid-term examinations. • Quizzes , Practical and viva-voce examinations. • End-term examinations |
| | Derive the barrier potential, barrier width, and current for step junction. | | |
| Unit II | Comprehend the working of bipolar junction transistors in different modes. | Lecture, Practical, Demonstration | |
| | Analyze the load line and operating point of transistors. | | |
| | Examine the characteristics of amplifiers and their classifications. | | |
| Unit III | Explore the effects of feedback in amplifiers and oscillation principles. | Lecture, Discussion, Practical | |
| | Determine the frequency of sinusoidal oscillators using Barkhausen's Criterion. | | |
| | Analyze the working of RC Phase-shift, Hartley, and Colpitts oscillators. | | |
| Unit IV | Understand the characteristics and applications of operational amplifiers. | Lecture, Practical, Demonstration | |
| | Analyze the frequency response and other parameters of operational amplifiers. | | |

| | | | |
|---|---|---|---|
| | Explore various applications of operational amplifiers. | | |
| | Study the concept of resistive network conversion and A/D conversion. | | |

**NOTICES:** All notices for the course will be displayed on A-Block, 2nd Floor Notice Board.

## GLOSSARY AND NOTES

**Programme Outcomes:** POs are statements that describe what the students graduating from any of the educational Programmes of the institution should be able to do on completion.

**Programme Specific Outcomes:** PSOs are statements that describe what the graduates of a specific educational Programme should be able to do on completion.

**Course Outcomes:** COs are statements that describe what students should be able to do on completion of the course.

**Program Articulation Matrix:** Program articulation matrix gives the correlation among CO & PO and CO & PSO. The strength of correlation is interpreted in three levels: weakly mapped (1), moderately mapped (2), strongly mapped (3).

***Teaching –Learning Methods**: Teaching –Learning Methods may include Lecture/Group Discussion/Presentation/Case-study/Demonstration using simulation or a tool/ Interview/ Quiz/Debate/Project/Field Project/Experiment etc.
****Mode of Evaluation**: Mode of Evaluation may include Assignment/Quiz/Test/Interview/Peer Review/Report/Presentation/Open Book Test/Evaluated Discussion Forum etc.

| **SCPH352** | Analog systems and applications lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 30 | | | | |
| **Pre-requisites/Exposure** | Basics of Physics | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**

1. Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer. To learn how charges behave through electric circuits.
2. Sessions on the review of scientific laboratory report writing, and on experimental data analysis.
3. Expand and exercise the students' physical intuition and thinking process through the experiments.
4. Interpretation of experimental data

**Course Outcomes**

On completion of this course, the students will be able to
CO1: Develop an understanding of various electronic components such as diodes, transistors, and op-amps, and analyze their characteristics in different configurations.
CO2: Apply theoretical knowledge to design and test electronic circuits such as amplifiers, oscillators, and converters as per given specifications, reflecting synthesis and evaluation skills.
CO3: Demonstrate the practical application of complex mathematical concepts in electronics, such as differentiating and integrating functions using op-amps.
CO4: Evaluate the performance of designed circuits and components such as solar cells and amplifiers, understanding the relationship between theory and practice in electronics.

**Catalog Description**
This course imparts the basic concepts of experimental physics. The course is design to give knowledge how to use basic instruments in laboratory and laboratory experiment protocols. The main focus is on data collection techniques and the data interpretation. For this purpose a series of experiments have been set. The difficulty level of experiments is set easy to moderate level due to introductory physics.

**Course Content**
At least 08 experiments from the following:
1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a two stage RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To design a digital to analog converter (DAC) of given specifications.
10. To design a precision Differential amplifier of given I/O specification using Op-amp.
11. To investigate the use of an op-amp as an Integrator.
12. To investigate the use of an op-amp as a Differentiator.
13. To design a circuit to simulate the solution of simultaneous equation and 1st/2ndorder differential equation.

**References for Laboratory Work:**
1. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, Mc-Graw Hill. OP-Amps

**Open Educational Resources:**

1. https://www.youtube.com/watch?v=BxbXnYFqygU&pp=ygVTdG8gc3R1ZHkgdGhlIHYtaSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSB6ZW5lciBkaW9kZSBhbmQgaXRzIHVzZSBhcyB2b2x0YWdlIHJlZ3VsYXRvciA%3D
2. https://www.youtube.com/watch?v=9GuB1SgHXEc&pp=ygVXLiBTdHVkeSBvZiBWLUkgJiBwb3dlciBjdXJ2ZXMgb2Ygc29sYXIgY2VsbHMsIGFuZCBmaW5kIG1heGltdW0gcG93ZXIgcG9pbnQgJiBlZmZpY2llbmN5
3. https://www.youtube.com/watch?v=BsbqB07Mwmo&pp=ygVSLlRvIHN0dWR5IHRoZSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSBCaXBvbGFyIEp1bmN0aW9uIFRyYW5zaXN0b3IgaW4gQ0UgY29uZmlndXJhdGlvbg%3D%3D
4. https://www.youtube.com/watch?v=E58rxqJB5kA&list=PL-IC1WV1OE4n9gVU3bQfBWsQhnmICRKYM
5. https://www.youtube.com/watch?v=ZZomhoZL-18&pp=ygVbVG8gZGVzaWduIGEgQ0UgdHJhbnNpc3RvciBhbXBsaWZpZXIgb2YgYSBnaXZlbiBn

YWluIChtaWQtZ2FpbikgdXNpbmcgdm9sdGFnZSBkaXZpZGVyIGJpYXMuIA%3D%3D

6. https://www.youtube.com/watch?v=QAHsqK8La1c&pp=ygVhVG8gc3R1ZHkgdGhlIGZyZXF1ZW5jeSByZXNwb25zZSBvZiB2b2x0YWdlIGdhaW4gb2YgYSB0d28gc3RhZ2UgUkMtY291cGxlZCB0cmFuc2lzdG9yICBhbXBsaWZpZXIuIA%3D%3D
7. https://www.youtube.com/watch?v=eg884iSHGok&pp=ygVGVG8gZGVzaWduIGEgcGhhc2Ugc2hpZnQgb3NjaWxsYXRvciBvZiBnaXZlbiBzcGVjaWZpY2F0aW9ucyB1c2luZyBCSlQuIA%3D%3D
8. https://www.youtube.com/watch?v=_TD0xG5FbCs&pp=ygVIVG8gZGVzaWduIGEgV2llbiBicmlkZ2Ugb3NjaWxsYXRvciBmb3IgZ2l2ZW4gZnJlcXVlbmN5IHVzaW5nIGFuIG9wLWFtcC4g
9. https://www.youtube.com/watch?v=upvw2uLJDeI&pp=ygVFVG8gZGVzaWduIGEgZGlnaXRhbCB0byBhbmFsb2cgY29udmVydGVyIChEQUMpIG9mIGdpdmVuIHNwZWNpZmljYXRpb25z
10. https://www.youtube.com/watch?v=2Gb16xH6g7g&pp=ygVXIFRvIGRlc2lnbiBhIHByZWNpc2lvbiBEaWZmZXJlbnRpYWwgYW1wbGlmaWVyIG9mIGdpdmVuIEkvTyBzcGVjaWZpY2F0aW9uIHVzaW5nIE9wLWFtcC4g
11. https://www.youtube.com/watch?v=PRPkvGjUFO4&pp=ygVKIFRvIGludmVzdGlnYXRlIHRoZSB1c2Ugb2YgYW4gb3AtYW1wIGFzIGFuIEludGVncmF0b3IgYW5kIERpZmZlcmVudGlhdG9yLiA%3D
12. https://www.youtube.com/shorts/nxThhTE1fVg

**Assessment & Evaluation**

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme and Course Mapping**

| Course Code& Title | | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH352 Analog systems and applications lab | CO 1 | 3 | 3 | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 3 |
| | CO 2 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 3 |
| | CO 4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit i | Analog systems and applications lab |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | The course will impart knowledge on how to use basic instruments in laboratory and laboratory experiment |
| Employability | - |
| Entrepreneurship | - |
| Skill development | Construction, functioning and uses of different electrical circuits, and e-electrical devices |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education |
| Poe/4th IR | Use of software and simulations |

**Teaching Plan:**

| Week | Topics | Reference Books/OER | Teaching/Learning Method |
|---|---|---|---|
| 1 | Introduction to Zener Diodes | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill, https://www.youtube.com/watch?v=BxbXnYFqygU&pp=ygVTdG8gc3R1ZHkgdGhlIHYtaSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSB6ZW5lciBkaW9kZSBhbmQgaXRzIHVzZSBhcyB2b2x0YWdlIHJlZ3VsYXRvciA%3D | Lecture and Lab |
| 2 | Study of V-I characteristics of a Zener diode | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill, https://www.youtube.com/watch?v=BxbXnYFqygU&pp=ygVTdG8gc3R1ZHkgdGhlIHYtaSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSB6ZW5lciBkaW9kZSBhbmQgaXRzIHVzZSBhcyB2b2x0YWdlIHJlZ3VsYXRvciA%3D | Lecture and Lab |

| | | | |
|---|---|---|---|
| 3 | Zener diode as a Voltage regulator | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=BxbXnYFqygU&pp=ygVTdG8gc3R1ZHkgdGhlIHYtaSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSB6ZW5lciBkaW9kZSBhbmQgaXRzIHVzZSBhcyB2b2x0YWdlIHJlZ3VsYXRvciA%3D | Lecture and Lab |
| 4 | Introduction to Solar Cells and their V-I & power curves | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill, https://www.youtube.com/watch?v=9GuB1SgHXEc&pp=ygVXLiBTdHVkeSBvZiBWLUkgJiBwb3dlciBjdXJ2ZXMgb2Ygc29sYXIgY2VsbHMsIGFuZCBmaW5kIG1heGltdW0gcG93ZXIgcG9pbnQgJiBlZmZpY2llbmN5 | Lecture and Lab |
| 5 | Finding maximum power point & efficiency of Solar Cells | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill, | Lecture and Lab |
| 6 | Introduction to Bipolar Junction Transistor (BJT) in CE configuration | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=BsbqB07Mwmo&pp=ygVSLlRvIHN0dWR5IHRoZSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSBCaXBvbGFyIEp1bmN0aW9uIFRyYW5zaXN0b3IgaW4gQ0UgY29uZmlndXJhdGlvbg%3D%3D | Lecture and Lab |
| 7 | Study of various biasing configurations of BJT | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=BsbqB07Mwmo&pp=ygVSLlRvIHN0dWR5IHRoZSBjaGFyYWN0ZXJpc3RpY3Mgb2YgYSBCaXBvbGFyIEp1bmN0aW9uIFRyYW5zaXN0b3IgaW4gQ0UgY29uZmlndXJhdGlvbg%3D%3D | Lecture and Lab |
| 8 | Designing a CE transistor amplifier of a given gain (mid-gain) | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=ZZomhoZL-18&pp=ygVbVG8gZGVzaWduIGEgQ0UgdHJhbnNpc3RvciBhbXBsaWZpZXIgb2YgYSBnaXZlbiBnYWluIChtaWQtZ2FpbikgdXNpbmcgdm9sdGFnZSBkaXZpZGVyIGJpYXMuIA%3D%3D | Lecture and Lab |

| | | | |
|---|---|---|---|
| | | | |
| 9 | Study of frequency response of voltage gain of a two-stage RC-coupled transistor amplifier | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=QAHsqK8La1c&pp=ygVhVG8gc3R1ZHkgdGhlIGZyZXF1ZW5jeSByZXNwb25zZSBvZiB2b2x0YWdlIGdhaW4gb2YgYSB0d28gc3RhZ2UgUkMtY291cGxlZCB0cmFuc2lzdG9yICBhbXBsaWZpZXIuIA%3D%3D | Lecture and Lab |
| 10 | Designing a Wien bridge oscillator and a phase-shift oscillator using op-amps | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=_TD0xG5FbCs&pp=ygVIVG8gZGVzaWduIGEgV2llbiBicmlkZ2Ugb3NjaWxsYXRvciBmb3IgZ2l2ZW4gZnJlcXVlbmN5IHVzaW5nIG9wLWFtcC4g | Lecture and Lab |
| 11 | Designing a digital to analog converter (DAC) | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=upvw2uLJDeI&pp=ygVFVG8gZGVzaWduIGEgZGlnaXRhbCB0byBhbmFsb2cgY29udmVydGVyIChEQUMpIG9mIGdpdmVuIHNwZWNpZmljYXRpb25z | Lecture and Lab |
| 12 | Designing a precision Differential amplifier using Op-amp | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill, https://www.youtube.com/watch?v=2Gb16xH6g7g&pp=ygVXIFRvIGRlc2lnbiBhIHByZWNpc2lvbiBEaWZmZXJlbnRpYWwgYW1wbGlmaWVyIG9mIGdpdmVuIEkvTyBzcGVjaWZpY2F0aW9uIHVzaW5nIE9wLWFtcC4g https://www.youtube.com/watch?v=2Gb16xH6g7g&pp=ygVXIFRvIGRlc2lnbiBhIHByZWNpc2lvbiBEaWZmZXJlbnRpYWwgYW1wbGlmaWVyIG9mIGdpdmVuIEkvTyBzcGVjaWZpY2F0aW9uIHVzaW5nIE9wLWFtcC4g | Lecture and Lab |
| 13 | Op-amp as an Integrator and | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/watch?v=PRPkvGjUFO4&pp=ygVKIFRvIGludmVzdGlnYXRlIHRoZSB1c2Ugb2YgYW4gb3AtYW1wIGFzIGFuIEludGVncmF0b3IgYW5kIERpZmZlcmVudGlhdG9yLiA%3D | Lecture and Lab |

| | | | |
|---|---|---|---|
| | Differentiator | | |
| 14 | Designing a circuit to simulate the solution of simultaneous equations and 1st/2nd order differential equations | Basic Electronics: A text lab manual, P.B.Zbar et al, Mc-Graw Hill https://www.youtube.com/shorts/nxThhTE1fVg | Lecture and Lab |

**Facilitating the Achievement of Course Learning Outcomes**

| **Course Learning Outcomes** | **Teaching Learning Activity** | **Assessment Task Methods** |
|---|---|---|
| Understand the fundamentals of diodes and demonstrate the application of Zener diode as a voltage regulator. | Lectures, Lab exercises | Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| Analyze the characteristics of BJT in CE configuration, design a transistor amplifier, and study the frequency response of voltage gain. | Lectures, Lab exercises | |
| Construct Wien bridge and phase shift oscillators, and design a digital to analog converter (DAC). | Lectures, Lab exercises | |
| Design a differential amplifier, utilize an op-amp as an Integrator and Differentiator, and design circuits to solve simultaneous and differential equations. | Lectures, Lab exercises | |

| SCPH304 | Themodynamics and Statistical Mechanics | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |

| | |
|---|---|
| **Pre-requisites/Exposure** | Classical Mechanics |
| **Co-requisites** | -- |

**Course Objectives**

1. To make them learn about the classical statistics and its applications.
2. To enable them to use classical theory of radiation to solve some problems of physics.
3. To give knowledge of quantum theory of radiation.
4. To impart knowledge about Bose Einstein statistics and Fermi Dirac statistics.

**Course Outcomes**

CO1: Understand the fundamental principles of thermodynamics and the laws governing energy interactions.
CO2: Analyze and apply the First and Second Laws of Thermodynamics to various thermodynamic processes and systems.
CO3: Comprehend the concept of entropy and its role in thermodynamic processes, including the Third Law.
CO4: Familiarity with statistical mechanics and its application to ideal gases, Bose-Einstein and Fermi-Dirac statistics, and their thermodynamic functions..

**Catalog Description**

This course imparts the basic concepts of classical statistics and its applications. It enables them to use classical theory of radiation to solve some problems of physics. This course give knowledge of quantum theory of radiation. The course introduces the basic concepts about Bose Einstein statistics and Fermi Dirac statistics.

**Course Content**

**UNIT-I** **13 Lecture Hours**

**Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between $C_P$ and $C_V$, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

**UNIT-II** **15 Lecture Hours**

**Second Law of Thermodynamics:** Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work, Heat Engines, Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin- Planck and Clausius Statements and their Equivalence. Carnot's Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

**Entropy:** Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy, Entropy of a perfect gas, Entropy Changes in Reversible and Irreversible processes with examples, Entropy of the Universe, Temperature–Entropy diagrams for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

**UNIT-III** **12 Lecture Hours**

**Classical Statistics:** Macrostate & Microstate, Elementary Concept of Ensemble, PhaseSpace, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System.

**UNIT-IV** **14 Lecture Hours**

**Bose-Einstein Statistics:** B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas.

**Fermi-Dirac Statistics:** Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas.

**Text Book:**

**TB1:** Thermal Physics, Agarwal and Prakash, Pragati Prakashan Educational Publishers.

**TB2:** Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

**TB3:** Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

**Reference Books:**

RB1: Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

RB2: Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

RB3: Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall

RB4: Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

RB5: An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

**Open Educational Resources (OER)**

https://byjus.com/physics/thermodynamics/

https://www.youtube.com/watch?v=8N1BxHgsoOw

https://www.youtube.com/watch?v=NyOYW07-L5g

https://www.youtube.com/watch?v=8xRFqrNyJCg&list=PLyqSpQzTE6M9iXvWVCopr67kKt61ntzIl

https://www.youtube.com/watch?v=Qz5D2bUQk4c&list=PLQCYtYck4nKwkiEyJ_mzuzz9aQla1Kvdh

https://www.youtube.com/watch?v=o1EinUCgFsw&list=PL74Pz7AXMAnOSPWBIzmZOpSs2KgchH3dP

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH304 / Themodynamics and Statistical Mechanics | CO1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |
| | CO2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |
| | CO3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |
| | CO4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 |

1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped

# Teaching Plan:

| Weekly Teaching Plan | Topic/Unit No. | Textbook / Reference Book / OER | Teaching-Learning Method |
|---|---|---|---|
| Week 1 | Introduction to Thermodynamics | TB1 | Lecture, Discussion |
| Week 2 | Zeroth Law of Thermodynamics | TB1 | Lecture, Discussion |
| Week 3 | First Law of Thermodynamics | https://byjus.com/physics/thermodynamics/ | Lecture, Discussion |
| Week 4 | Applications of the First Law | https://www.youtube.com/watch?v=8N1BxHgsoOw | Lecture, Discussion |
| Week 5 | Second Law of Thermodynamics | https://www.youtube.com/watch?v=NyOYW07-L5g | Lecture, Discussion |
| Week 6 | Carnot Cycle and Efficiency | TB2 | Lecture, Discussion |
| Week 7 | Entropy and Clausius Theorem | TB2/RB2 | Lecture, Discussion |
| Week 8 | Entropy Changes and Second Law | RB2 | Lecture, Discussion |
| Week 9 | Third Law of Thermodynamics | RB1 | Lecture, Discussion |
| Week | Classical Statistics and | RB3 | Lecture, Discussion |

| | | | |
|---|---|---|---|
| 10 | Macrostate/Microstate | | |
| Week 11 | Maxwell-Boltzmann Distribution Law | Textbook | Lecture, Discussion |
| Week 12 | Partition Function and Ideal Gas | TB2 | Lecture, Discussion |
| Week 13 | Bose-Einstein Statistics and Degenerate Bose Gas | TB3 | Lecture, Discussion |
| Week 14 | Fermi-Dirac Statistics and Degenerate Fermi Gas | https://www.youtube.com/watch?v=Qz5D2bUQk4c&list=PLQCYtYck4nKwkiEyJ_mzuzz9aQla1Kvdh | Lecture, Discussion |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CLO) | Teaching-Learning Activity | Assessment Task Methods |
|---|---|---|---|
| Unit - I | Understand thermodynamics principles and laws | Lectures, Class Discussions | Class Tests, Quizzes |
| | Analyze thermodynamic processes and systems | Problem Solving Sessions, Worked Examples | Homework Assignments, In-class Exercises |
| | Comprehend entropy and its role in processes | | |
| | Apply statistical mechanics to ideal gases and particles | | |
| Unit - II | Understand thermodynamics principles and laws | Lectures, Class Discussions | Class Tests, Quizzes |
| | Analyze thermodynamic processes and systems | Problem Solving Sessions, Worked Examples | Homework Assignments, In-class Exercises |
| | Comprehend entropy and its role in processes | | |
| | Apply statistical mechanics to ideal gases and particles | | |
| Unit - III | Understand thermodynamics principles and laws | Lectures, Class Discussions | Class Tests, Quizzes |
| | Analyze thermodynamic processes and systems | Problem Solving Sessions, Worked Examples | Homework Assignments, In-class Exercises |
| | Comprehend entropy and its role in processes | | |
| | Apply statistical mechanics to ideal gases and particles | | |
| Unit - IV | CO1: Understand thermodynamics principles and laws | Lectures, Class Discussions | Class Tests, Quizzes |
| | CO2: Analyze thermodynamic processes and systems | Problem Solving Sessions, Worked Examples | Homework Assignments, In-class Exercises |
| | CO3: Comprehend entropy and its role in processes | | |
| | CO4: Apply statistical mechanics to ideal gases and particles | | |

| SCPH306 | ELECTROMAGNETIC THEORY | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Electricity and Magnetism | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To familiarize the student with the fundamentals of electromagnetic waves, Maxwell's equations and electromagnetic energy density associated with electromagnetic waves.
2. To understand the factors governing the propagation of EM waves in unbounded and bounded media.
3. To acquire knowledge of polarization of electromagnetic waves.
4. Applications of wave guides and optical fibres.

**Course Outcomes**

On completion of this course, the students will be able to

- CO1: understand the concepts related to Electromagnetic Wave Propagation in both bounded and unbounded media, ideas of different polarization of Electromagnetic waves, the principle of rotatory polarization and Fresnel's theory of optical rotation.
- CO2: Apply Maxwell's equations and the concept of Electromagnetic Energy Density to solve problems in electromagnetism, the laws of reflection and refraction, Brewster's law, and the concept of total internal reflection in practical applications.
- CO3: Analyze wave propagation in different media using Maxwell's equations, gauge transformations, and boundary conditions,evaluate optical rotation phenomena using Biot's laws for Rotatory Polarization and Fresnel's Theory.
- CO4: Construct and evaluate solutions for wave propagation in different media, and polarization phenomena, create their understanding and interpretation of the Fresnel's Theory of optical rotation and will be able to design experiments for its verification

**Catalog Description**

This course is intended to cover the concepts of electromagnetic waves and their properties and propagation. It discusses the propagation of electromagnetic waves through bounded and unbounded media. This course also makes a foundation for advanced courses such as optical fiber communication and waveguides.

**Course Content**

**Unit 1** **20 Contact Hours**

**Maxwell Equations:** Review of Maxwell's equations. Displacement Current. Vectorand Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density (12 Lectures)

**Unit II** **12 Contact Hours**

**EM Wave Propagation in Unbounded Media:** EM Wave Propagation in Unbounded Media, Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth.

**EM Wave in Bounded Media:** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media, Laws of

Reflection & Refraction, Brewster's law, Total internal reflection,

**Unit III** **12 Contact Hours**

**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization, Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates.

**Unit IV** **10 Contact Hours**

**Rotatory Polarization:** Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnel's theory, Specific rotation nad Laurent's half-shade polarimeter. (5 Lectures)

**Text books:**

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

**Reference book**

1. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
2. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
3. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
4. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
5. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
6. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

**Additional Books for Reference**

1. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
2. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
3. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press

**Open Education Resources**

- https://www.khanacademy.org/science/electrical-engineering/ee-electromagnetic-fields/ee-magnetic-circuits/v/maxwell-s-equations-introduction
- https://phet.colorado.edu/en/simulation/em-waves
- https://phet.colorado.edu/en/simulation/polarization
- https://www.physicsclassroom.com/class/refrn
- https://www.youtube.com/watch?v=LF3qn9uTdkc
- https://nptel.ac.in/courses/115/105/115105068/
- https://www.youtube.com/watch?v=az9x-wrObYg

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme and Course Mapping**

| .Course Code & Title | Course Outcome | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCPH306 Electromagnetic Theory | CO1 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 2 | 2 |
| | CO2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 3 | 3 |
| | CO3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| | CO4 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Maxwell equations |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Fundamentals of electromagnetic waves, Maxwell's equations and electromagnetic energy density associated with electromagnetic waves. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | EM wave propagation |
| Local | - |

| | |
|---|---|
| Regional | - |
| National | - |
| Global | Understanding of the factors governing the propagation of EM waves in unbounded and bounded media |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Polarization of electromagnetic waves |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of polarization of electromagnetic waves |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Wave guides |
| Local | - |
| Regional | - |
| National | - |
| Global | Insight about wave guides and optical fibres |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4$^{th}$ IR | Use of software and simulations |

## Teaching Plan

| Week | Topics | Reference Books/OER | Teaching Learning Method |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Review of Maxwell's equations. Displacement Current | D.J. Griffiths; M.N.O. Sadiku;<br><br>https://www.khanacademy.org/science/electrical-engineering/ee-electromagnetic-fields/ee-magnetic-circuits/v/maxwell-s-equations-introduction | Lectures; Interactive discussion |
| 2 | Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge | D.J. Griffiths; T.L. Chow, https://www.khanacademy.org/science/electrical-engineering/ee-electromagnetic-fields/ee-magnetic-circuits/v/maxwell-s-equations-introduction | Lectures; Problem-solving sessions |
| 3 | Boundary Conditions at Interface between Different Media | M.A.W. Miah; https://phet.colorado.edu/en/simulation/em-waves | Lectures; Demonstrations |
| 4 | Wave Equations. Plane Waves in Dielectric Media | D.J. Griffiths; M.N.O. Sadiku, https://phet.colorado.edu/en/simulation/em-waves | Lectures; Problem-solving sessions |
| 5 | Poynting Theorem and Poynting Vector | D.J. Griffiths; G. Lehner, https://nptel.ac.in/courses/115/105/115105068/ | Lectures; Interactive discussion |
| 6 | Electromagnetic (EM) Energy Density | D.J. Griffiths; Willian H. Hayt; https://nptel.ac.in/courses/115/105/115105068/ | Lectures; Demonstrations |
| 7 | EM Wave Propagation in Unbounded Media, Plane EM waves through vacuum and isotropic dielectric medium | M.N.O. Sadiku; T.L. Chow, https://www.physicsclassroom.com/class/refrn | Lectures; Problem-solving sessions |

| | | | |
|---|---|---|---|
| 8 | Propagation through conducting media, relaxation time, skin depth | M.A.W. Miah; R.S. Kshetrimayun, https://www.physicsclassroom.com/class/refrn | Lectures; Demonstrations |
| 9 | Reflection & Refraction of plane waves at plane interface between two dielectric media, Laws of Reflection & Refraction, Brewster's law, Total internal reflection | M.A.W. Miah; Willian H. Hayt; https://www.physicsclassroom.com/class/refrn | Lectures; Interactive discussion |
| 10 | Description of Linear, Circular and Elliptical Polarization, Fresnel's Formula | D.J. Griffiths; G. Lehner; University of Colorado Boulder - Physics Department | Lectures; Demonstrations |
| 11 | Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction | D.J. Griffiths; M.N.O. Sadiku, https://www.youtube.com/watch?v=az9x-wrObYg | Lectures; Problem-solving sessions |
| 12 | Nicol Prism. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates | D.J. Griffiths; G. Lehner, https://www.youtube.com/watch?v=az9x-wrObYg | Lectures; Demonstrations |
| 13 | Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation | D.J. Griffiths; T.L. Chow; https://www.youtube.com/watch?v=LF3qn9uTdkc | Lectures; Problem-solving sessions |

| | | | |
|---|---|---|---|
| 14 | Calculation of angle of rotation, Experimental verification of Fresnel's theory, Specific rotation and Laurent's half-shade polarimeter | D.J. Griffiths; M.N.O. Sadiku; G. Lehner, https://www.youtube.com/watch?v=LF3qn9uTdkc | Lectures; Lab activity |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Course Learning Outcomes (CLO) | Teaching Learning Activity (TLA) | Assessment Task Methods (ATM) |
|---|---|---|---|
| I | Understand the basic principles of Maxwell's equations and displacement current. Apply vector and scalar potentials in various contexts. Analyze different media using the boundary conditions. Calculate electromagnetic field energy density based on given conditions. | Lectures, Problem-solving sessions, Demonstrations, Group discussions. | Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| II | CLO1: Understand the principles of electromagnetic wave propagation in unbounded media. Analyze the behavior of electromagnetic waves in vacuum and isotropic dielectric medium. | Lectures, Problem-solving sessions, Demonstrations, Group discussions. | |
| III | CLO1: Identify different types of electromagnetic wave polarization. Understand and analyze light propagation in uniaxial crystals. | Lectures, Problem-solving sessions, Demonstrations, Group discussions. | |
| IV | Understand the principles of rotatory polarization and optical rotation. Calculate the angle of rotation based on Fresnel's theory. | Lectures, Problem-solving sessions, Demonstrations, Group discussions. | |

| | | | | | |
|---|---|---|---|---|---|
| | Nanomaterials | | | | |
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 54 | | | | |
| **Pre-requisites/Exposure** | Basic knowledge in Materials Science, Physics, Chemistry, Chemical Engineering, and Nanotechnology. | | | | |
| **Co-requisites** | | | | | |

**Course Description**

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims at teaching the students underlying principles of analytical techniques that are commonly used for the evaluation of structural, morphological, optical, thermal, mechanical and electrical properties of nanomaterials.

**Course Outcomes**

- CO1: Identify and describe the various types of characterization techniques, including microscopy, spectroscopy, X-ray techniques, and methods for measuring mechanical, magnetic, electrical, and thermal properties of materials.
- CO2: Apply the knowledge learned to determine the appropriate characterization technique for a given material or situation.
- CO3: Synthesize the knowledge acquired from different characterization techniques to form a comprehensive understanding of the material's properties.
- CO4: Design an experiment utilizing one or more characterization techniques based on the material's properties and the information required.

**Unit 1.** **15 Contact Hours**

**Basics of Characterization Techniques:** Types of characterization techniques, Basics, Importance. Structural and compositional characterization tools, Difference between Microscopy and Spectroscopy, Optical Microscopy, Atomic Force Microscopy, Scanning Electron Microscopy, Transmission electron Microscopy, Scanning Tunneling Microscopy.

**Unit 2.** **12 Contact Hours**

**Spectroscopy**: UV visible spectroscopy, Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy (X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy & Ultra Violet Photoelectron Spectroscopy).

**Unit 3.** **12 Contact Hours**

**X-ray techniques:** X-ray diffraction (XRD) technique, particle size determination using XRD, Applications of XRD, Electron diffraction and its application, neutron diffraction and its applications, X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy.

**Unit 4.** **20 Contact Hours**

**Mechanical, Magnetic, electrical and Thermal properties measurement:** Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions, Hardness testing of thin films and coatings, Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of Nanomaterials, Dielectric constant measurement, Differential Thermal Analysis (DTA), Differential scanning calorimetry (DSC).

**Reference Books**

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977
2. Transmission Electron Microscopy: A Textbook for Materials Science David B Williams, C Barry Carter, (1996) Plenum Press, New York
3. Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press
5. Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and Bussiness media publications, 2011
6. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009

**Open Education Resources**

- https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/
- https://nanohub.org/
- https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy
- https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials
- https://www.merlot.org/merlot/viewMaterial.htm?id=637562
- https://www.khanacademy.org/science/physics/light-waves
- http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/
- https://ncl.cancer.gov/resources/assay-cascade-protocols
- https://openstax.org/details/books/college-physics-ap-courses
- https://www.coursera.org/learn/material-behavior

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme and Course Mapping**

| **Course Code & Title** | **Course Outcome** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS108 Characterisa | CO1 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 2 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| tion techniques of nanomaterials | CO2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| | CO4 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |

Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

### Unit 1: Basics of Characterization Techniques

| Indicator | Relevant Course Content |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Microscopy techniques like optical microscopy and electron microscopy |
| Employability | practical skills in materials characterization using Microscopic techniques. |
| Entrepreneurship | innovation in materials technology. |
| Skill Development | materials science and characterization. |
| Professional Ethics | - |
| Gender | - |
| Human Values | |
| Environment & Sustainability | |
| SDG | responsible materials development in alignment with sustainability goals. |
| Nep 2020 | Complies with the national education framework and curriculum guidelines. |
| Poe/4th IR | integration of advanced materials science into the evolving technological landscape. |

### Unit 2: Spectroscopy:

| Indicator | Relevant Course Content |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Spectroscopy techniques like UV-VIS spectroscopy, FTIR spectroscopy |
| Employability | practical skills in materials characterization using Spectroscopic techniques. |
| Entrepreneurship | innovation in materials technology. |
| Skill Development | materials science and characterization. |
| Professional Ethics | - |
| Gender | - |
| Human Values | |

| | |
|---|---|
| Environment & Sustainability | |
| SDG | responsible materials development in alignment with sustainability goals. |
| Nep 2020 | Complies with the national education framework and curriculum guidelines. |
| Poe/4th IR | integration of advanced materials science into the evolving technological landscape. |

**Unit 3: X-ray techniques**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | X-Ray diffraction |
| Employability | practical skills in materials characterization using X-Ray techniques. |
| Entrepreneurship | innovation in materials technology. |
| Skill Development | materials science and characterization. |
| Professional Ethics | - |
| Gender | - |
| Human Values | |
| Environment & Sustainability | |
| SDG | responsible materials development in alignment with sustainability goals. |
| Nep 2020 | Complies with the national education framework and curriculum guidelines. |
| Poe/4th IR | integration of advanced materials science into the evolving technological landscape. |

**Unit 4: Mechanical, Magnetic, electrical and Thermal properties measurement:**

| **Indicator** | **Relevant Course Content** |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Properties measurement using UV-VIS spectroscopy, TGA, DSC, VSM etc. |
| Employability | practical skills in materials property measurement. |
| Entrepreneurship | innovation in materials technology. |
| Skill Development | materials science and characterization. |
| Professional Ethics | - |
| Gender | - |
| Human Values | |
| Environment & Sustainability | |
| SDG | responsible materials development in alignment with sustainability goals. |
| Nep 2020 | Complies with the national education framework and curriculum guidelines. |
| Poe/4th IR | integration of advanced materials science into the evolving technological landscape. |

# Teaching Plan:

| **Week** | **Topic** | **Reference Books/OER** | **Teaching/Learning Method** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Introduction to Characterization Techniques | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,<br><br>https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/ | Lectures |
| 2 | Types of characterization techniques, Basics, Importance | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,<br><br>https://nanohub.org/ | Lectures and group discussions |
| 3 | Structural and compositional characterization tools | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,<br><br>https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials | Lectures and lab exercises |
| 4 | Microscopy Techniques: Optical, Atomic Force, Scanning Electron | Transmission Electron Microscopy: A Textbook for Materials Science,<br><br>https://ncl.cancer.gov/resources/assay-cascade-protocols | Lectures and lab demonstrations |
| 5 | Transmission electron Microscopy and Scanning Tunneling Microscopy | Transmission Electron Microscopy: A Textbook for Materials Science,<br><br>https://nanohub.org/ | Lectures and hands-on lab sessions |
| 6 | Introduction to Spectroscopy: UV visible spectroscopy | Fundamentals of Fourier Transform Infrared Spectroscopy, https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy | Lectures and lab exercises |
| 7 | Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy | Fundamentals of Fourier Transform Infrared Spectroscopy, https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy | Lectures and lab exercises |
| 8 | Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy | Impedance Spectroscopy: Theory, Experiment, and Applications,<br>https://www.khanacademy.org/science/physics/light-waves | Lectures and hands-on lab sessions |

| | | | |
|---|---|---|---|
| 9 | Introduction to X-ray techniques: X-ray diffraction (XRD) technique | Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/ | Lectures and lab exercises |
| 10 | Particle size determination using XRD, Applications of XRD | Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/ | Lectures and group discussions |
| 11 | Electron diffraction and its application, neutron diffraction and its applications | Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/ | Lectures and hands-on lab sessions |
| 12 | Introduction to Measurement of Mechanical, Magnetic, electrical and Thermal properties | Nanoindentation, https://www.coursera.org/learn/material-behavior | Lectures and lab demonstrations |
| 13 | Nanoindentation principles, Hardness testing, Vibration Sample Magnetometer, Impedance Spectroscopy | Nanoindentation, Coursera – Material Behavior https://www.coursera.org/learn/material-behavior | Lectures and hands-on lab sessions |
| 14 | Measurement of Magnetic and electrical properties of Nanomaterials, Dielectric constant measurement, Differential Thermal Analysis (DTA) | Nanoindentation, Coursera – Material Behavio https://www.coursera.org/learn/material-behavior | Lectures and lab exercises |

## Facilitating the Achievement of Course Learning Outcomes

| Unit | Learning Outcome | Teaching/Learning Activity | Assessment Task |
|---|---|---|---|
| 1. | Students will understand the types, basics, | Lecture on types of characterization | Presentations and class |

| | | | |
|---|---|---|---|
| | and importance of characterization techniques, and distinguish between microscopy and spectroscopy. | techniques, labs for microscopy techniques. | discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| 2. | Students will understand and apply the principles of various spectroscopy techniques (UV, IR, Raman, PL, and Photoelectron Spectroscopy). | Lecture on spectroscopy principles, labs for different spectroscopy techniques. | |
| 3. | Students will understand and apply X-ray diffraction techniques, including particle size determination and applications of XRD, electron diffraction, and neutron diffraction. | Lecture on X-ray techniques, labs on XRD, electron diffraction, and neutron diffraction. | |
| 4. | Students will comprehend the principles of measurement techniques for mechanical, magnetic, electrical and thermal properties. | Lecture on principles of property measurement, labs for hardness testing, impedance spectroscopy, dielectric constant measurement, DTA, and DSC. | |

| **UNS109** | Characterization Techniques of Nanomaterials-I Lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 30 | | | | |
| **Pre-requisites/Exposure** | Basic knowledge in Materials Science, Physics, Chemistry, Chemical Engineering, and Nanotechnology. | | | | |
| **Co-requisites** | | | | | |

## Course Description

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims at teaching the students underlying principles of analytical techniques that are commonly used for the evaluation of structural, morphological, optical, thermal, mechanical and electrical properties of nanomaterials.

## Course Outcomes

CO1: Evaluate and interpret structural and morphological properties of nanomaterials using X-Ray Diffraction and SEM/EDX/TEM techniques, demonstrating an ability to link these properties to material composition and structure.

CO2: Perform and interpret composition and thermal analysis of nanomaterials using FTIR spectroscopy and TGA/DSC, applying this understanding to infer material stability and transformations under thermal stress.

CO3: Apply UV-VIS spectrophotometry to study the optical properties of nanomaterials, focusing on determining the bandgap, and comprehend its impact on material performance in various applications.

CO4: Conduct and analyze mechanical property tests on nanomaterials through nanoindentation/hardness tests, using these outcomes to comprehend the relationship between material structure, composition, and mechanical performance.

**List of Experiments**

1. To analyse the structural properties such as crystallite size and lattice parameters using X-Ray Diffraction technique.

2. To study the morphological properties of nanomaterials using SEM/EDX/TEM.

3. To perform composition analysis using FTIR spectroscopy.

4. To Study thermal properties of nanomaterials using TGA/DSC.

5. To study the optical properties such as bandgap of a nanomaterial using UV-VIS spectrophotometer.

6. To study the mechanical properties of nanomaterials using nanoindentation/hardness test.

**Reference Books**

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977

2. Transmission Electron Microscopy: A Textbook for Materials Science

David B Williams, C Barry Carter, (1996) Plenum Press, New York

3. Impedance Spectroscopy: Theory, Experiment, and Applications,

E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.

4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC

Press

5. Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and

Bussiness media publications, 2011

6. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L.

Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009

**Open Education Resources**

- https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D
- https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D
- https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D
- https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D
- https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D

**Assessment & Evaluation**

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme and Course Mapping**

| Course Code& Title | CO/PO, PSO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNS109 Characterization | CO1 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 2 | 2 |
| | CO2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Techniques of Nano materials-I Lab | CO3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 3 |
| | CO4 | 2 | 2 | 1 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 3 |

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Indicator | Relevant Course Content |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Characterisation techniques I.e. XRD, FTIR, SEM, TEM |
| Employability | practical skills in materials characterization |
| Entrepreneurship | innovation in materials technology. |
| Skill Development | materials science and characterization. |
| Professional Ethics | - |
| Gender | - |
| Human Values | |
| Environment & Sustainability | |
| SDG | responsible materials development in alignment with sustainability goals. |
| Nep 2020 | Complies with the national education framework and curriculum guidelines. |
| Poe/4th IR | integration of advanced materials science into the evolving technological landscape. |

## Teaching Plan:

| Week | Topics | Reference Books/Open Educational Resources | Teaching-Learning Method |
|---|---|---|---|
| 1 | Introduction to X-Ray | Elements of X-ray Diffraction B. D. Cullity https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVz | Lecture, Group |

| | | | |
|---|---|---|---|
| | Diffraction | aW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D | Discussion |
| 2 | In-depth understanding of X-Ray Diffraction | Elements of X-ray Diffraction B. D. Cullity, https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D | Lecture, Practical Session |
| 3 | SEM/EDX/TEM: Basic Concepts | Transmission Electron Microscopy: A Textbook for Materials Science, David B Williams, C Barry Carter, https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D<br><br>https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D<br><br>https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D | Lecture, Practical Session |
| 4 | Advanced study of SEM/EDX/TEM | Transmission Electron Microscopy: A Textbook for Materials Science, David B Williams, C Barry Carter https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D<br><br>https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D<br><br>https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D | Lecture, Practical Session |
| 5 | Introduction to FTIR Spectroscopy | Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D | Lecture, Group Discussion |
| 6 | In-depth understanding of FTIR Spectroscopy | Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D | Lecture, Practical Session |

| | | | |
|---|---|---|---|
| 7 | Midterm Review and Examination | All References | Review, Examination |
| 8 | TGA/DSC: Basic Concepts | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=bENSsj4rfJc&pp=ygU7VG8gU3R1ZHkgdGhlcm1hbCBwcm9wZXJ0aWVzIG9mIG5hbm9tYXRlcmlhbHMgdXNpbmcgVEdBL0RTQy4%3D | Lecture, Group Discussion |
| 9 | Advanced study of TGA/DSC | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=bENSsj4rfJc&pp=ygU7VG8gU3R1ZHkgdGhlcm1hbCBwcm9wZXJ0aWVzIG9mIG5hbm9tYXRlcmlhbHMgdXNpbmcgVEdBL0RTQy4%3D | Lecture, Practical Session |
| 10 | Introduction to UV-VIS Spectrophotometry | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D | Lecture, Group Discussion |
| 11 | In-depth understanding of UV-VIS Spectrophotometry | Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D | Lecture, Practical Session |
| 12 | Introduction to Nanoindentation /hardness test | Nanoindentation, By Anthony C Fischercripps, https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D | Lecture, Group Discussion |

| | | | |
|---|---|---|---|
| 13 | In-depth understanding of Nanoindentation /hardness test | Nanoindentation, By Anthony C Fischercripps, https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D | Lecture, Practical Session |
| 14 | Review of all Topics and Final Examination Preparation | All References | Review, Examination Preparation |

## Facilitating the Achievement of Course Learning Outcomes

| **Learning Outcomes** | **Teaching & Learning Activities** | **Assessment Methods** |
|---|---|---|
| Evaluate and interpret structural properties of nanomaterials, with an understanding of crystallite size and lattice parameters. | Lectures on the principles and applications of X-ray diffraction, followed by laboratory experiments. | Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| Perform and interpret composition and morphological analysis of nanomaterials, linking these properties to material composition and structure. | Lectures on the theory and practical aspects of SEM/EDX/TEM and FTIR, with subsequent practical sessions in the lab. | |
| Analyze the thermal and optical properties of nanomaterials, understanding material stability under thermal stress and the concept of bandgap. | Lectures on the principles and uses of TGA/DSC and UV-VIS Spectrophotometry, followed by lab experiments. | |
| Assess the mechanical properties of nanomaterials, understanding the link between material structure, composition, and mechanical performance. | Lectures on the principles and applications of nanoindentation/hardness tests, followed by lab experiments. | |

| SEC018 | Electrical circuits and network skills | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 2 | 0 | 0 | 2 |
| **Total Contact Hours** | 27 | | | | |
| **Pre-requisites/Exposure** | Basics of Electronics | | | | |
| **Co-requisites** | -- | | | | |

**Course Description**

The aim of this course is to recall the basic concepts of resistance, current, voltage in electricity and applying them in solving electrical circuits. Next, recalling the semiconductor devices like diodes. Further, this course aims in moving to advanced stages by applying the learnt knowledge in understanding clipper and clamper circuits to modify the input waveform in various ways.

**Course Outcomes**

**CO1:** Apply Ohm's law and Kirchhoff's laws to analyze basic electrical circuits.

**CO2**: Analyze DC and AC sourced electrical circuits, including inductance, capacitance, and impedance.

**CO3:** Utilize diodes in various applications, including voltage regulation, clipping, and clamping circuits**.**

**UNIT-I** **7 Lectures**

**Basic Electricity Principles:** Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with mustimeter, voltmeter and ammeter. Kirchhoff's voltage and current laws. Voltage divider and current divider circuits.

**UNIT-II** **10 Lectures**

**Understanding Electrical Circuits:** Main electric circuit elements and their combination. Rules to analyse DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Inductance, capacitance, and impedance. Rules to analyse AC sourced electrical circuits. Real, imaginary and complex power components of AC source.

**UNIT-III** **10 Lectures**

**Diodes:** Mathematical modelling of diode, forward and reverse biasing in diodes, Zener diode and its application in voltage regulation. Application of diodes in clipper and clamper circuits.

**Electrical Wiring:** Different types of conductors and cables. Basics of wiring-Star and delta connection. Relationship between phase voltages, currents and line voltages, currents respectively. Conversion of star to delta network and delta to star network.

**Text Books**

TB1: A text book in Electrical Technology - B L Theraja - S Chand & Co.
TB2. A text book of Electrical Technology - A K Theraja.

**Reference Books/Materials**

RB1: Performance and design of AC machines - M G Say ELBS Edn.

**Open Educational Resources (OER)**

https://nptel.ac.in/courses/108104139
https://nptel.ac.in/courses/108102097
https://www.youtube.com/watch?v=EdUAecpYVWQ&list=PLwjK_iyK4LLBj2yTYPYKFKdF6kIg0ccP2
https://www.youtube.com/watch?v=GHhcyH99inE

**Assessment & Evaluation**

| **Components** | **Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Code and Title** | **Course Outcome** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEC018/ Electrical circuits and network skills | **CO1** | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | - | - | - |
| | **CO2** | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | - | - | - |
| | **CO3** | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | - | - | - |

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Basic electricity principles and circuits |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Demonstration of the utility of voltmeter, ammeter and multimeter in measurement of voltage, current, power and impedance of any circuit |
| Employability | Designing of voltmeter, ammeter and multimeter |
| Entrepreneurship | |
| Skill development | Working of voltmeter, ammeter and multimeter |
| Professional ethics | Professional competence and due care |
| Gender | - |

| | |
|---|---|
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Electrical drawing and symbols |
| Local | - |
| Regional | - |
| National | - |
| Global | Familiarization with the working of electrical machines such as transformer, generator and motors etc. |
| Employability | Troubleshooting any fault in an electrical circuit using multimeter and other tools |
| Entrepreneurship | - |
| Skill development | Troubleshooting any fault in an electrical circuit using multimeter and other tools |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Solid-state devices |
| Local | - |
| Regional | - |
| National | - |
| Global | Familiarization with the working of electrical machines such as transformer, generator and motors etc. |
| Employability | Troubleshooting any fault in an electrical circuit using multimeter and other tools |
| Entrepreneurship | - |
| Skill development | Troubleshooting any fault in an electrical circuit using multimeter and other tools |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Electrical wiring |
| Local | - |
| Regional | - |
| National | - |
| Global | Design and trouble shoots the electrical circuits and networks |
| Employability | Knowledge of electrical wiring, connectors and cables, |
| Entrepreneurship | - |
| Skill development | Knowledge of electrical wiring, connectors and cables, |
| Professional ethics | Professional competence and due care |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Promoting high-quality research<br>Vocational education |

| | |
|---|---|
| Poe/4th IR | Hands on experience, projects, internship |

# Teaching Plan:

| Week | Topic/Unit No. | Textbook / Reference Book / OER | Teaching-Learning Method |
|---|---|---|---|
| 1 | UNIT-I: Basic Electricity Principles | TB1 | Lecture, Discussions, Examples |
| 2 | UNIT-I (Contd.): Ohm's Law, Series-Parallel Combinations | TB1 | Lecture, Practical/Lab |
| 3 | UNIT-I (Contd.): AC and DC Electricity | https://nptel.ac.in/courses/108104139 https://nptel.ac.in/courses/108102097 | Lecture, Practical/Lab |
| 4 | UNIT-I (Contd.): Kirchhoff's Laws | TB2 | Lecture, Discussions, Practical/Lab |
| 5-6 | UNIT-I (Contd.): Voltage and Current Divider Circuits | TB2 | Lecture, Practical/Lab |
| 7 | UNIT-II: Understanding Electrical Circuits | https://nptel.ac.in/courses/108102097 | Lecture, Discussions, Examples |
| 8 | UNIT-II (Contd.): Rules to Analyze DC Sourced Circuits | TB2 | Lecture, Practical/Lab |
| 9 | UNIT-II (Contd.): Inductance, Capacitance, and Impedance | TB2 | Lecture, Discussions, Practical/Lab |
| 10 | UNIT-II (Contd.): Rules to Analyze AC Sourced Circuits | TB2 | Lecture, Practical/Lab |

| | | | |
|---|---|---|---|
| 11 | UNIT-II (Contd.): Real, Imaginary and Complex Power | TB2 | Lecture, Practical/Lab |
| 12 | UNIT-III: Diodes - Mathematical Modelling and Biasing | https://www.youtube.com/watch?v=EdUAecpYVWQ&list=PLwjK_iyK4LLBj2yTYPYKFKdF6kIg0ccP2 | Lecture, Discussions, Practical/Lab |
| 13 | UNIT-III (Contd.): Application of Diodes in Circuits | TB2 | Lecture, Practical/Lab |
| 14 | UNIT-III (Contd.): Electrical Wiring - Types of Conductors and Cables | https://www.youtube.com/watch?v=GHhcyH99inE | Lecture, Discussions, Practical/Lab |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes (CLOs) | Teaching-Learning Activities | Assessment Task Methods |
|---|---|---|---|
| UNIT-I | Apply Ohm's law and Kirchhoff's laws to analyze basic electrical circuits. | Lectures, discussions, and examples on Ohm's law, Kirchhoff's laws, and circuit analysis. | Presentations and class discussions. Assignments and class tests Student presentations. Mid-term examinations. Quizzes End-term examinations |
| | Analyze DC and AC electrical circuits with inductance, capacitance, and impedance. | Hands-on experiments with electrical circuits and components. | |
| | Utilize diodes in various applications, including voltage regulation, clipping, and clamping circuits. | Simulation exercises and practical demonstrations of diode circuits. | |
| UNIT-II | Understand the main electric circuit elements and their combinations. | Lectures on circuit elements and their behavior in circuits. | |
| | Analyze DC sourced electrical circuits, including current and voltage drop across circuit elements. | Circuit analysis exercises and solving problems related to DC circuits. | |

| | | | |
|---|---|---|---|
| | Analyze AC sourced electrical circuits, including real, imaginary, and complex power components. | Practical experiments on AC circuits and power calculations. | |
| UNIT-III | Understand the mathematical modeling and forward/reverse biasing in diodes. | Theoretical discussions and derivations of diode characteristics. | |
| | Apply Zener diode for voltage regulation and diodes in clipper/clamper circuits. | Practical applications of Zener diodes in voltage regulation. | |
| | Understand different types of conductors, cables, and basics of electrical wiring. | Demonstrations and discussions on various types of conductors and wiring connections. | |
| | Understand the relationship between phase voltages, currents, and line voltages, currents. | Interactive sessions on star and delta connections in electrical systems. | |

**Semester VII**

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|
| 1 | SCPH401 | Nuclear Physics | 4 |
| 2 | SCPH403 | Classical dynamics | 4 |
| 3 | SCCH401 | Research Methodology | 4 |
| 4 | UNS110 | Synthesis of Nanomaterials-II | 4 |
| 5 | UNS111 | Synthesis of Nanomaterials-II lab | 1 |
| Total | 17 | Total | |

| SCPH401 | Nuclear Physics | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 56 | | | | |
| **Pre-requisites/Exposure** | Basic Modern Physics | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To familiarize students with the constituents of the nucleus and their intrinsic properties, such as mass, radii, charge density, binding energy, average binding energy, and their variations with mass number.
2. To provide a comprehensive understanding of the main features of the binding energy versus mass number curve and the N/A plot.
3. To introduce the concepts of angular momentum, parity, magnetic moment, and electric moments in nuclei.
4. To explore nuclear excited states and their characteristics.

**Course Outcomes**
On completion of this course, the students will be able to

CO1. Understand and Apply Nuclear Models.
CO 2. Describe Radioactivity Decay Processes.
CO 3. Analyze Nuclear Reactions
CO 4. Understand Interaction of Nuclear Radiation with Matter.

**Catalog Description**
This course is intended to cover the concepts of nucleus, its constituents, properties and interactions of its constituents. It discusses the radioactive decay, elementary particles and various conservation laws governing the interaction of elementary particles. This course also makes a foundation for advanced courses on Nuclear and Particle physics and Nuclear Radiations.

**Course Content**

**Unit I: 14 Contact Hours**

**General Properties of Nuclei:** Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

**Nuclear Models:** Liquid drop model approach, semi empirical mass formula andsignificance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model.

**Unit II: 14 Contact Hours**

**Radioactivity decay:** (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β- decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

**Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction,.

**Unit III: 14 Contact Hours**

**Interaction of Nuclear Radiation with matte**r: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

**Unit IV: 1 Contact Hours**

**Particle Accelerators:** Accelerator facility available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

**Particle physics:** Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quarkmodel, color quantum number and gluons.

**Suggested Text Books:**

1. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.

**Advanced Readings [RB]:**

1Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2 Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3 Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4 Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5 Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6 Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
7 Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP Institute of Physics Publishing, 2004).
8 Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
9 Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
10 Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991)

**Open Educational Resources (OER)**

https://www.youtube.com/watch?v=MnPJgXyXHW8
https://www.youtube.com/watch?v=RTlThUySwUE
https://www.youtube.com/watch?v=Rd0CJje59bE

https://www2.lbl.gov/abc/wallchart/chapters/03/2.html
https://www.iaea.org/newscenter/news/cyclotrons-what-are-they-and-where-can-you-find-them#:~:text=A%20cyclotron%20is%20a%20type,are%20bombarded%20by%20these%20protons.
https://www.physik.uni-hamburg.de/en/iexp/gruppe-schleper/lehre/detectors-methods-ss18/documents/detectors-and-analysis-methods-ss-18-notes-04.pdf

**Assessment & Evaluation**

| **Components** | **Quiz/Presentation / Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Objectives (CO)** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1: Understand and Apply Nuclear Models** | **2** | **2** | **1** | **1** | **1** | **2** | **1** | **1** | **1** | **1** | **2** | **1** | **1** | **1** |
| **CO2: Describe Radioactivity Decay Processes** | **2** | **2** | **1** | **1** | **1** | **2** | **1** | **1** | **1** | **1** | **2** | **1** | **1** | **1** |
| **CO3: Analyze Nuclear Reactions** | **2** | **2** | **1** | **1** | **0** | **2** | **1** | **1** | **1** | **1** | **2** | **1** | **0** | **0** |
| **CO4: Interaction of Nuclear Radiation** | **2** | **2** | **0** | **0** | **1** | **2** | **1** | **1** | **1** | **1** | **2** | **0** | **1** | **1** |

1= "lightly mapped," 2= "moderately mapped," and 3="strongly mapped,"

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Nuclei models |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding of constituents of nucleus, their intrinsic properties and nuclear models. |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |

| | |
|---|---|
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Nuclear reactions |
| Local | - |
| Regional | - |
| National | - |
| Global | Understanding the processes involved in radioactive decay and types of nuclear reactions |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Interaction of nuclear radiation with matter radioactivity decay |
| Local | - |
| Regional | - |
| National | - |
| Global | Knowledge of interaction of nuclear radiation with matter, detectors and accelerators for nuclear radiations |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Particle physics give heading of the unit here (if applicable) |
| Local | - |
| Regional | - |
| National | - |
| Global | Insight about various types of elementary particles and their interactions |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4$^{th}$ IR | Use of software and simulations |

**Teaching Plan**

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|
| Week 1 | General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. | TB1/CH2<br><br>20.5 Energy of Nuclear Reactions & Nuclear Binding Energy \| General Chemistry - YouTube | Class test/presentation/Assignments/Quizzer/ Viva/Project<br>Class test/presentation/Assignments/Quizzer/ Viva/Project |
| Week 2 | Nuclear Models: Liquid drop model approach, semi-empirical mass formula and significance of its various terms, condition of nuclear stability, two-nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of the shell model. | TB1/CH9<br>https://www.youtube.com/watch?v=RTlThUySwUE https://www.youtube.com/watch?v=Rd0CJje59bE | |
| Week 3 | Radioactivity decay: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger-Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. | TB1/CH3-6<br>https://www2.lbl.gov/abc/wallchart/chapters/03/2.html | |
| Week 4 | Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross-section, Concept of compound and direct Reaction, resonance | TB1/CH10-11 | |

| | | | |
|---|---|---|---|
| | reaction. | | |
| Week 5 | Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. | | |
| Week 6 | Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of a photo-multiplier tube (PMT). | TB1/CH7<br>https://www.physik.uni-hamburg.de/en/iexp/gruppe-schleper/lehre/detectors-methods-ss18/documents/detectors-and-analysis-methods-ss-18-notes-04.pdf | |
| Week 7 | Detector for Nuclear Radiations (Continued): Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. | TB1/CH7 | |
| Week 8 | Particle Accelerators: Accelerator facility available in India: Van-de-Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. | TB1/CH12<br>https://www.iaea.org/newscenter/news/cyclotrons-what-are-they-and-where-can-you-find-them#:~:text=A%20cyclotron%20is%20a%20type,are%20bombarded%20by%20these%20protons | |
| Week 9 | Particle physics: Particle interactions; basic features, types of particles and their families. Symmetries and Conservation Laws: energy and momentum, angular momentum, | TB1/CH18 | |

| | | | |
|---|---|---|---|
| Week 10 | parity, baryon number, Lepton number, Isospin, Strangeness, and charm, concept of the quark model, color quantum number, and gluons. | TB1/CH18 | Class test/presentation/Assignments/Quizzer/ Viva/Project |
| Week 11 | Particle physics (Continued): Fundamental forces and their carriers, elementary particle interactions and decays. | TB1/CH18 | |
| Week 12 | Particle physics (Continued): Particle accelerators and colliders, high-energy particle physics experiments. | TB1/CH18 | |
| Week 13 | Particle physics (Continued): Beyond the Standard Model (BSM) physics,. | TB1/CH18 | |
| Week 14 | dark matter, and cosmology , Revision and Review of Key Concepts | TB1/CH19 | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Gain proficiency in comprehending and applying nuclear models. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to deliver lecture on the relevant topic. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Develop the ability to describe various radioactivity decay processes. | | |
| **3** | Acquire the skill to analyze different types of nuclear reactions. | | |
| **4** | Understand the interaction between nuclear radiation and matter. | | |

| | | | | | |
|---|---|---|---|---|---|
| **SCPH403** | Classical Dynamics | L | T | P | C |
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 52 | | | | |
| **Pre-requisites/Exposure** | Basic Mathematical Physics | | | | |
| **Co-requisites** | | | | | |

**Course Objectives**

1. To familiarize the student with the e drawbacks of Newtonian approach and necessity of new approaches to solve problems involving the classical mechanical systems.
2. To understand the mechanics of small amplitude oscillations and normal modes of oscillations.
3. To acquire knowledge of special theory of relativity and understand two-body decay of an unstable particle.
4. To understand the concepts of fluid dynamics in terms of classical mechanics.

**Course Outcomes**

On completion of this course, the students will be able to

CO1. Define and understand basic mechanical concepts involving the dynamic motion of classical mechanical systems.

CO2. Solve the problems related to potential energy, oscillations and normal mode of oscillations of classical mechanical systems.

CO3. Solve problems of special theory of relativity using the Lagrangian and Hamiltonian formulations of classical mechanics

CO4. Apply classical dynamics to the problems in fluid dynamics.

**Catalog Description**

This course is intended to familiarize the students about the drawbacks of Newtonian mechanics and solve the problems using classical mechanics. It discusses the motion of a mechanical system using Lagrange-Hamilton formalism. It also presents the classical formalism of special theory of relativity and fluid dynamics.

**Course Content**

**UNIT I** **16 Contact Hours**

**Classical Mechanics of Point Particles:** Review of Newtonian Mechanics; Applicationto the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler- Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators

**UNIT II** **14 Contact Hours**

**Hamiltonian formulation:** Canonical momenta & Hamiltonian. Hamilton's equations of motion. Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

**Small Amplitude Oscillations:** Minima of potential energy and points of stable equilibrium, expansion

of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.

**UNIT III** **12 Contact Hours**

**Special Theory of Relativity:** Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Spacetime diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Fourmomentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. (33 Lectures)

**UNIT IV** **10 Contact Hours**

**Fluid Dynamics:** Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

**Suggested Text Books**

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
2. Classical Mechanics, J.C. Upadhyaya, 2nd Edn. 2005, Himalaya Publishing House

**Advanced Readings**

1. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
2. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
3. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
4. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
5. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
6 Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
7. Mechanics, D.S.Mathur, 2012, S.Chand

**Open Educational Resources (OER)**

https://en.wikipedia.org/wiki/Spacetime_diagram
https://en.wikipedia.org/wiki/Four-force
https://www.researchgate.net/profile/Mohamed_Mourad_Lafifi/post/In_a_robust_control_system_design_using_mixed-sensitivity_approach_the_sensitivity_is_constant_at_0_db_isnt_is_supposed_to_be_high-pass_filter/attachment/59d63ab079197b8077997c75/AS:407064284286977@1474063096225/download/NotesCh12+Coupled+Oscillators+and+Normal+Modes.pdf
https://mathsci.kaist.ac.kr/~nipl/am621/lecturenotes/Euler-Lagrange_equation.pdf

**Assessment & Evaluation**

| Components | Quiz/Presentation / Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Objectives (CO) | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| CO2 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| CO3 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| CO4: | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |

(Note: The numbers 1, 2, and 3 represent "lightly mapped," "moderately mapped," and "strongly mapped," respectively. Higher numbers indicate a stronger mapping between the Course Objectives and the Program Outcomes/Program Specific Outcomes.)

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Classical mechanics of point particles |
|---|---|
| Local | - |
| Regional | - |
| National | - |
| Global | Problems involving the classical mechanical systems |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit ii | Small amplitude oscillations |
| Local | - |
| Regional | - |
| National | - |
| Global | Problems related to potential energy, oscillations |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iii | Special theory of relativity |
| Local | - |

| | |
|---|---|
| Regional | - |
| National | - |
| Global | Knowledge of special theory of relativity |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| Unit iv | Fluid dynamics |
| Local | - |
| Regional | - |
| National | - |
| Global | Concepts of fluid dynamics in terms of classical mechanics |
| Employability | - |
| Entrepreneurship | - |
| Skill development | - |
| Professional ethics | - |
| Gender | - |
| Human values | - |
| Environment & sustainability | - |
| SDG | Quality education (4), decent work and economic growth (8) |
| Nep 2020 | Towards a more holistic and multidisciplinary education<br>Promoting high-quality research |
| Poe/4th IR | Projects and group discussion |

**Teaching Plan**

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| Week1 | Review of Newtonian Mechanics; Motion of a charge particle in electric and magnetic fields - gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations. | TB1/CH2<br>TB2/CH2 | Class test/presentation /Assignments/Quizzer/ Viva/Project |
| Week 2 | One-dimensional examples of the Euler-Lagrange equations - Simple Harmonic Oscillations and falling body in uniform gravity. Applications to simple systems such as coupled oscillators. | TB2/CH2<br>https://mathsci.kaist.ac.kr/~nipl/am621/lecturenotes/Euler- | Class test/presentation /Assignments/Quizzer/ Viva/Project |

| | | | |
|---|---|---|---|
| | | Lagrange_equation.pdf | |
| Week3 | Hamiltonian formulation: Canonical momenta & Hamiltonian. Hamilton's equations of motion. Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations. | TB1/CH8<br><br>TB2/CH3 | |
| Week 4 | Particle in a central force field - conservation of angular momentum and energy. Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations. | TB2/CH9<br><br>https://www.researchgate.net/profile/Mohamed_Mourad_Lafifi/post/In_a_robust_control_system_design_using_mixed-sensitivity_approach_the_sensitivity_is_constant_at_0_db_isnt_is_supposed_to_be_high-pass_filter/attachment/59d63ab079197b8077997c75/AS:407064284286977@1474063096225/download/NotesCh12+Coupled+Oscillators+and+Normal+Modes.pdf | |
| Week 5 | Example of N identical masses connected in a linear fashion to (N -1) - identical springs. Review of concepts covered so far. | TB2/CH9 | |
| Week 6 | Special Theory of Relativity: Postulates of Special Theory of Relativity, Lorentz Transformations, Minkowski space, the invariant interval, light cone, and world lines. | TB2/CH12 | |
| Week 7 | Spacetime diagrams, Time-dilation, length contraction, and twin paradox. Four-vectors: space-like, time-like, and light-like. Four-velocity and acceleration. Metric and alternating tensors. | TB2/CH12<br>TB1/CH7<br>https://en.wikipedia.org/wiki/Spacetime_diagram | |

| | | | |
|---|---|---|---|
| Week 8 | Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. | TB2/CH14<br><br>https://en.wikipedia.org/wiki/Four-force | |
| Week 9 | Application to two-body decay of an unstable particle. Fluid Dynamics: Density and pressure P in a fluid, | TB2/CH14 | |
| Week 10 | . an element of fluid and its velocity, , Poiseuille's equation for the flow of a liquid through a pipe. | RB7/CH15 | |
| Week 11 | continuity equation and mass conservation, streamline motion, laminar flow, Review and Recap of all topics | RB7/CH15 | |
| Week 12 | Navier-Stokes equation, qualitative description of turbulence, Reynolds number. | RB7/CH15 | |
| Week 13 | Practice problems and problem-solving session. | | |
| | | | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Define and comprehend fundamental mechanical concepts related to the dynamic motion of classical mechanical systems. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to deliver lecture on the relevant topic. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Apply problem-solving skills to address issues concerning potential energy, oscillations, and normal modes of classical systems. | | |
| **3** | Utilize Lagrangian and Hamiltonian formulations of classical mechanics to solve problems involving special theory of relativity. | | |
| **4** | Apply principles of classical dynamics to solve problems within the realm of fluid dynamics. | | |

| SCCH401 | Research Methodology | L | T | P | C |
|---|---|---|---|---|---|
| Version 1.0 | | 4 | 0 | 0 | 4 |
| Total Contact Hours | 52 | | | | |
| Pre-requisites/Exposure | Basics of Nanomaterial | | | | |
| Co-requisites | -- | | | | |

## COURSE OBJECTIVES

The course will enable the student-teacher to:

- Master literature survey techniques for efficient chemical information retrieval.
- Develop proficiency in ethical scientific communication and proper citation practices.
- Acquire knowledge of safe chemical handling and disposal, adhering to ethical guidelines.
- Gain expertise in accurate data analysis, utilizing statistical tools and chemometrics.
- Foster research aptitude through understanding the scientific method and experimental design in chemistry.

### COURSE OUTCOMES (CO)

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

**CO1:** Learn to find and use various types of chemical information sources.

**CO2:** Digital Proficiency: Utilize digital tools for accessing and staying updated on chemistry research.

**CO3:** Scientific Writing: Develop skills for writing research papers with integrity and precision.

**CO4:** Safety and Ethics: Understand and practice safe chemical handling and ethical conduct.

**CO5:** Data Analysis: Gain expertise in analyzing chemical data using statistical techniques.

**CO6:** Research Competence: Build a solid foundation for conducting meaningful chemistry research.

### CATALOG DESCRIPTION

This course introduces students to essential research methodologies in chemistry. It covers effective information sourcing from diverse print and digital resources, emphasizing literature survey techniques, accessing e-journals, and utilizing databases. Scientific writing skills are honed through proper citation practices, methods description, and ethical considerations. Chemical safety protocols, hazardous material handling, and ethical waste disposal are comprehensively addressed. Statistical data analysis techniques, including correlation, regression, and ANOVA, are taught for sound research interpretation. The course cultivates research aptitude, emphasizing the scientific method, experimental design, and critical analysis in the context of chemistry.

## COURSE CONTENT

**UNIT I: Literature Survey:**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

**UNIT II**

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

**UNIT III**

Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

**UNIT IV**

**Data Analysis**

The Investigative Approach: Making and Recording Measurements. SI Units and their use.Scientific method and design of experiments. Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear

equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis

**Suggested Text Books**

"Chemical Information for Chemists: A Primer" by Judith N. Currano and Dana L. Roth

"Scientific Writing and Communication: Papers, Proposals, and Presentations" by Angelika H. Hofmann

"Chemistry Safety for Students and Practitioners: Laboratory Safety for Chemistry Students" by Robert H. Hill Jr. and David C. Finster

"Basic Statistics for the Behavioral Sciences" by Gary W. Heiman

"Experimental Design for the Life Sciences" by Graeme D. Ruxton and Nick Colegrave

**Open Educational Resources (OER)**

ChemCollective - Provides virtual labs and scenarios for teaching chemistry concepts: ChemCollective

ChemGuide - A collection of online chemistry resources including tutorials and quizzes: ChemGuide

MIT OpenCourseWare: Principles of Chemical Science - Offers free course materials, including lecture notes and assignments: MIT OCW - Principles of Chemical Science

ChemCollective Virtual Labs - Interactive virtual labs for various chemistry topics: ChemCollective Virtual Labs

Project Gutenberg - Provides free access to a wide range of classic scientific literature: Project Gutenberg

Merlot Chemistry Portal - A collection of chemistry resources from various universities and institutions: Merlot Chemistry

Chem1 Virtual Textbook - An extensive collection of chemistry tutorials and explanations: Chem1 Virtual Textbook

ChemCollective Concept Tests - Interactive concept tests for assessing understanding of chemistry concepts: ChemCollective Concept Tests

OpenStax Chemistry - A comprehensive open-source chemistry textbook: OpenStax Chemistry

Khan Academy Chemistry - Offers free video lessons and practice exercises on various chemistry topics: Khan Academy Chemistry

**Assessment & Evaluation**

| Components | Assignment | Mid Term Examination | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

**Programme And Course Mapping**

| Course Code and Title | Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Research Methodology / SCCH401 | CO1 | 2 | 2 | 1 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 3 | 2 | 1 | 2 |
| | CO2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 2 |
| | CO3 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |
| | CO4 | 2 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 |
| | CO5 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 |
| | CO6 | 1 | 3 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 1 | 3 |

# Teaching Plan:

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|
| 1-2 | Unit I - Literature Survey | TB-Chapters 1-2 | Lectures, Discussions |
| 3-4 | Unit I - Literature Survey (cont.) | TB-Chapters 3-4 | Lectures, Case Studies |
| 5-6 | Unit II - Information Technology | TB-Chapters 5-6 | Lectures, Group Discussions |
| 7-8 | Unit II - Information Technology (cont.) | TB-Chapters 7-8 | Lectures, Case Studies |
| 9-10 | Unit III - Chemical Safety | TB-Chapters 9-10 | Lectures, Guest Lecture |
| 11-12 | Unit III - Chemical Safety (cont.) | TB-Chapters 11-12 | Lectures, Practical Demonstrations |
| 13-14 | Unit IV - Data Analysis | TB-Chapters 13-14 | Lectures, Field Trip |

## Facilitating the Achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Literature Survey: Students will learn to navigate various chemical literature sources, from print to digital, distinguishing | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) | • Presentations and class discussions. • Assignments and class tests. • Student |

| | | | |
|---|---|---|---|
| | between primary, secondary, and tertiary sources. They will effectively utilize databases, grasp journal abbreviations, and understand abstracts for staying updated with current research. | Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Unit II - Information Technology and Library Resources: Through this unit, students will develop digital proficiency, accessing e-journals, web resources, and tools for scientific research. They will master ethical scientific writing, ensuring clear communication through proper citations, both orally and in writing. | | |
| **3** | Unit III - Chemical Safety and Ethical Handling: This unit will equip students with essential chemical safety knowledge, enabling them to work safely in labs. They will also gain an understanding of ethical considerations related to chemical research and responsible waste disposal. | | |
| **4** | Unit IV - Data Analysis: Students will acquire expertise in accurate measurement, statistics, and data analysis relevant to chemistry. They will learn to interpret results effectively, supporting evidence-based conclusions and contributing to scientific discussions. | | |

| UNS110 | Synthesis of Nanomaterials-II | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 52 | | | | |
| **Pre-requisites/Exposure** | Basics of Nanomaterial | | | | |
| **Co-requisites** | -- | | | | |

**Course Objectives**:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.
3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

**Course Outcomes:**

**CO1** Students will be able to explain the principles of film growth and differentiate between various deposition techniques, such as PVD, CVD, ALD, and sol-gel films.

**CO2** Students will comprehend the properties and applications of carbon fullerenes, nanotubes, ordered and random mesoporous structures, and other special nanomaterials.

**CO3** Students will acquire practical skills in lithography and nanomanipulation techniques like STM, AFM, and soft lithography for nanostructure fabrication.

**CO4** Students will be able to identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.

**CATALOG DESCRIPTION**

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

**Course Content**

**UNIT-I** **14 Lectures**

**Two-Dimensional Nanostructures: Thin Films**

Introduction; Fundamentals of Film Growth; Vacuum Science; Physical Vapor Deposition (PVD): (Evaporation, Molecular beam epitaxy (MBE), Sputtering, Comparison of evaporation and sputtering); Chemical Vapor Deposition (CVD):(Typical chemical reactions,Reaction kinetics,Transport phenomena,5CVD methods,Diamond films by CVD);

Atomic Layer Deposition (ALD); Superlattices; Self-Assembly:(Monolayers of organosilicon or alkylsilane derivatives, Monolayers of alkanethiols and sulfides, Monolayers of carboxylic acids, amines

alkylsilane derivativesand alcohols); Langmuir-Blodgett Films; Electrochemical Deposition; Sol-Gel Films

**UNIT-II** **14 Lectures**

**Special Nanomaterials**

Introduction; Carbon Fullerenes and Nanotubes (Carbon fullerenes,Fullerene-derived crystals, Carbon nanotubes); Ordered mesoporous structures; Random mesoporous structures; Crystalline microporous materials: zeolites; Metal-oxide structures; Metal-polymer structures; Oxide-polymer structures; Organic-Inorganic Hybrids :(Class I hybrids, Class II hybrids);Intercalation Compounds; Nanocomposites and Nanograined Materials;

**UNIT-III** **14 Lectures**

**Nanostructures Fabricated by Physical Techniques**

Introduction;Lithography:(Photolithography,Phase-shifting photolithography, Electron beam lithography,X-ray lithography,Focused ion beam (FIB) lithography,Neutral atomic beam lithography); Nanomanipulation and Nanolithography : (Scanning tunneling microscopy (STM), Atomic force microscopy (AFM) ,Near-field scanning optical microscopy (NSOM) ,Nanomanipulation,Nanolithography); Soft Lithography: (Microcontact printing, Molding, Nanoimprint, Dip-pen nanolithography); Assembly of Nanoparticles and Nanowires: (Capillary forces, Dispersion interactions, Shear force assisted assembly, Electric-field assisted assembly, Covalently linked assembly, Gravitational field assisted assembly, Template-assisted assembly); Other Methods for Microfabrication

**UNIT IV** **10 Lectures**

**Applications of Nanomaterials**

Introduction;Molecular Electronics and Nanoelectronics;Nanobots; Biological Applications of Nanoparticles; Catalysis by Gold Nanoparticles; Band Gap Engineered Quantum Devices: (Quantum well devices, Quantum dot devices);Nanomechanics;Carbon Nanotube Emitters; Photoelectrochemical Cells; Photonic Crystals and Plasmon Waveguides: (Photonic crystals,Plasmon waveguides)

**Suggested Text Books**

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

**Advanced Readings:**

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

**Open Educational Resources (OER)**

https://news.mit.edu/2015/explained-chemical-vapor-deposition-0619

https://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_22.php
https://www.youtube.com/watch?v=aOVU2aqgqe8
https://www.youtube.com/watch?v=dw9IvpilfUo
https://www.youtube.com/watch?v=1WGEMYDLsNs
https://en.wikipedia.org/wiki/Nanocomposite#:~:text=Nanocomposite%20is%20a%20multiphase%20solid,that%20make%20up%20the%20material.

**Assessment & Evaluation**

| **Components** | **Quiz/Presentation / Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

| **Course Objectives (CO)** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| CO2 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| CO3 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 1 |
| CO4 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |

(Note: The numbers 1, 2, and 3 represent "lightly mapped," "moderately mapped," and "strongly mapped," respectively. Higher numbers indicate a stronger mapping between the Course Objectives and the Program Outcomes/Program Specific Outcomes.)

**RELEVANCE OF THE COURSE TO VARIOUS INDICATORS**

| Unit i | Two-Dimensional Nanostructures: Thin Films |
|---|---|
| Local | Enhancing local industries with advanced thin film technologies. |
| Regional | Contributing to regional growth in electronics, surface treatments, and material science research. |
| National | Supporting national industries in electronics, advanced materials, and research & development. |
| Global | Aligning with global electronics & communications market trends and |

| | |
|---|---|
| | technological advancements. |
| Employability | Preparing students for careers as thin film technologists, surface engineers, or researchers in the field. |
| Entrepreneurship | Enabling entrepreneurial ventures in nano-film production and advanced surface treatments. |
| Skill development | Developing skills in film growth, PVD, CVD, ALD techniques, and thin film characterization methods. |
| Professional ethics | Promoting ethical methods in nano-film production, material sourcing, and laboratory practices. |
| Gender | Encouraging gender diversity in nanotechnology roles through equal opportunities. |
| Human values | Emphasizing the responsible use of nanotechnology for the betterment of society. |
| Environment & sustainability | Promoting eco-friendly methodologies and waste reduction in thin film production. |
| Unit ii | Special Nanomaterials |
| Local | - Enhancing local materials and electronics sectors with specialized nanomaterials like carbon fullerenes, nanotubes, and ordered mesoporous structures. |
| Regional | - Contributing to regional academic and industrial research capabilities in material science, electronics, and advanced materials. |
| National | Supporting national advancements in material science, electronics, and research & development sectors. |
| Global | Aligning with global trends in research and development of specialized nanomaterials, encouraging international collaborations. |
| Employability | - Providing career opportunities in electronics, materials science, and R&D roles with expertise in specialized nanomaterials. |
| Entrepreneurship | Fostering entrepreneurial ventures in the production and research of advanced nanomaterials. |
| Skill development | Developing skills in the synthesis and characterization of specialized nanomaterials like carbon fullerenes, nanotubes, and mesoporous structures. |
| Professional ethics | Promoting ethical practices in material sourcing, research, and responsible handling of advanced nanomaterials. |
| Gender | Encouraging gender diversity in material science research and applications, ensuring equal opportunities. |
| Human values | Emphasizing the responsible and ethical use of specialized nanomaterials for societal benefits. |
| Environment & sustainability | Encouraging eco-friendly practices in the synthesis and application of specialized nanomaterials. |
| Unit iii | Nanostructures Fabricated by Physical Techniques |
| Local | Strengthening local research institutions and industries with knowledge of advanced fabrication techniques like lithography, nanomanipulation, and nanolithography. |
| Regional | Enhancing regional research and industrial capabilities in microfabrication, advanced materials, and surface science. |
| National | Contributing to national advancements in microfabrication, electronics, and nanotechnology research sectors. |
| Global | Aligning with global trends in microfabrication techniques, fostering |

| | |
|---|---|
| | international research collaborations. |
| Employability | Providing career opportunities in research and development, electronics manufacturing, and microfabrication industries. |
| Entrepreneurship | Enabling entrepreneurial ventures in microfabrication and advanced material production using techniques such as soft lithography and nanomanipulation. |
| Skill development | Developing practical skills in lithography, nanolithography, and nanomanipulation, essential for microfabrication and material research. |
| Professional ethics | Emphasizing ethical practices in research, laboratory work, and responsible handling of advanced materials. |
| Gender | Encouraging gender diversity in material science research and microfabrication roles. |
| Human values | Promoting the responsible and ethical use of advanced fabrication techniques for societal benefits. |
| Environment & sustainability | Encouraging eco-friendly practices in microfabrication, including waste reduction and sustainable materials. |
| Unit iv | Applications of Nanomaterials |
| Local | Enhancing local research institutions and industries with applications in molecular electronics, nanobots, and advanced materials. |
| Regional | Contributing to regional technological advancements in electronics, biotechnology, and nanomechanics. |
| National | Supporting national innovation in electronics, biotechnology, and materials science, driving economic growth. |
| Global | Aligning with global trends in nanoelectronics, biotechnological applications, and quantum devices. |
| Employability | Preparing students for diverse career opportunities in nanoelectronics, biotechnology, catalysis, and advanced material applications. |
| Entrepreneurship | Fostering entrepreneurial ventures in nanotechnology applications, molecular electronics, and advanced material innovations. |
| Skill development | Developing skills in the practical application of nanomaterials in diverse sectors like electronics, medicine, and energy. |
| Professional ethics | Emphasizing ethical considerations in the application of nanomaterials, ensuring safety, and responsible practices. |
| Gender | Encouraging gender diversity in nanotechnology applications and research, ensuring equal opportunities for all. |
| Human values | Promoting the responsible and ethical application of nanomaterials for the betterment of society. |
| Environment & sustainability | Encouraging sustainable practices in the application of nanomaterials, including eco-friendly energy solutions and biodegradable materials. |
| SDG | Supporting SDG goals like Goal 3 (Good Health and Well-being), Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 11 (Sustainable Cities and Communities) through diverse applications of nanomaterials. |
| Nep 2020 | Aligning with the National Education Policy's emphasis on multidisciplinary education, application-based learning, and critical thinking. |
| Poe/4$^{th}$ IR | Preparing students for the Fourth Industrial Revolution with knowledge of applications of nanomaterials in the age of cyber-physical systems, IoT, and biotechnological advancements. |

# Teaching Plan

| Weekly Teaching Plan | Topic/Unit No. | Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER] | Teaching-Learning Method |
|---|---|---|---|
| **Week 1** | Introduction to Two-Dimensional Nanostructures: Thin Films,Fundamentals of Film Growth,Vacuum Science and Importance in Thin Film Deposition | TB1/CH5 | Class test/presentation/Assignments/Quizzer/Viva/Project |
| **Week 2** | Physical Vapor Deposition (PVD) Techniques: Evaporation.Molecular Beam Epitaxy (MBE) and its Applications, | https://www.youtube.com/watch?v=aOVU2aqgqe8 TB1/CH5 | Class test/presentation/Assignments/Quizzer/Viva/Project |
| **Week 3** | Sputtering Technique and Comparison with Evaporation, Introduction to Chemical Vapor Deposition (CVD) and its Basics | TB1/CH5 https://news.mit.edu/2015/explained-chemical-vapor-deposition-0619 | |
| **Week 4** | Typical Chemical Reactions in CVD, Reaction Kinetics and Transport Phenomena in CVD, Different CVD Methods and their Advantages/Disadvantages | TB1/CH5 | |
| **Week 5** | Diamond Films by Chemical Vapor Deposition (CVD), Introduction to Atomic Layer Deposition (ALD) and its Mechanism | TB1/CH5 | |
| **Week 6** | Langmuir-Blodgett Films: Preparation and Characterization, Electrochemical Deposition of Nanostructures | TB1/CH5 | |
| **Week 7** | superlattices: Fabrication and Properties, Self-Assembly of Nanostructures: Monolayers and their Applications | TB1/CH5 | |
| **Week 8** | Sol-Gel Films: Synthesis and Applications, Introduction to Special Nanomaterials | TB1/CH5 | |

| | | | |
|---|---|---|---|
| **Week 9** | Carbon Fullerenes: Structure and Properties, Carbon Nanotubes: Types and Applications | TB1/CH6<br><br>RB4/CH3<br><br>https://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_22.php<br><br>RB3.CH4-6 | |
| **Week 10** | Ordered and Random Mesoporous Structures, Crystalline Microporous Materials: Zeolites and their Uses | TB1/CH6<br><br>https://www.youtube.com/watch?v=1WGEMYDLsNs<br>https://www.youtube.com/watch?v=1WGEMYDLsNs | |
| **Week 11** | Metal-Oxide Structures: Synthesis and Properties, Metal-Polymer and Oxide-Polymer Nanocomposites | TB1/CH6 | |
| **Week 12** | Organic-Inorganic Hybrids: Class I and Class II Hybrids, Intercalation Compounds and their Applications | TB1/CH6 | |
| **Week 13** | Nanostructures Fabricated by Physical Techniques, Lithography Techniques: Photolithography, Electron Beam Lithography, and more | TB1/CH7<br><br>https://www.youtube.com/watch?v=dw9IvpilfUo<br>RB3/CH1 | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Learn how to fabricate thin films | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) | • Presentations, quizzers and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term |
| **2** | Students will comprehend the properties and applications of special nanomaterials like grapheme, CNT etc | | |

| | | | |
|---|---|---|---|
| **3** | Students will acquire practical skills in lithography and nanomanipulation techniques. | Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | examinations. |
| **4** | Students will be able to identify and analyze real-world applications of nanomaterials | | |

| **UNS111** | Synthesis of Nanomaterials-II Lab | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 0 | 0 | 2 | 1 |
| **Total Contact Hours** | 26 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | Synthesis of Nanomaterials | | | | |

**Course Objectives**:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.
3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

**Course Outcomes:**

**CO1** Students will be able to explain the principles of film growth and differentiate between various deposition techniques, such as solid state reaction method, coprecipitation method, and sol-gel films.

**CO2** Students will comprehend the properties and applications of magneticl nanomaterials.

**CO3** Students will comprehend the properties and applications of dielectric nanomaterials.

**CO4** Students will be able to identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.

**CATALOG DESCRIPTION**

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

**Course Content**

1, Preparation of Polystyrene film using solvent evaporation technique.
2. Preparation of magnetite particles using coprecipitation method.
3. Preparation of ferrofluid using water and magnetite particles,
4 Study the stability of magnetite particles in water and vegetable oil.
5. Prepare calcium titanate using solid state reaction method.
6 Find the opticle band gap of magnetite particles.
7. Make pallet of calcium titanate powder, sinter and polish.
8. Find the density of pallet using Archimedes principle.

**Suggested Text Books**

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

**Advanced Readings:**

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, Stephane Evoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

**Open Educational Resources (OER)**

https://doi.org/10.1021/ma001440d
https://pubs.acs.org/doi/abs/10.1021/ma000094x
https://www.sciencedirect.com/science/article/abs/pii/S0927775708000721
https://www.sciencedirect.com/science/article/abs/pii/S0167577X08005740
https://pubs.acs.org/doi/abs/10.1021/ed076p943
https://www.sciencedirect.com/science/article/abs/pii/S0304885305011406
https://www.sciencedirect.com/science/article/abs/pii/S0021979705004935
https://www.sciencedirect.com/science/article/abs/pii/S0021979705005515
https://doi.org/10.1063/1.108974
https://link.springer.com/article/10.1007/s10853-006-0103-y
https://www.youtube.com/watch?v=4q9Bh48RTxg
https://www.youtube.com/watch?v=YpbNyDzpB3A

**Assessment & Evaluation**

| Components | Conduct of Experiment | Lab Record/Viva Voce | Attendance | End Term Examination |
|---|---|---|---|---|
| Weightage (%) | 20 | 20 | 10 | 50 |

## Programme And Course Mapping

| Course Objectives (CO) | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 | PSO4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1: Principles of film growth | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | | 1 | 1 |
| CO2: Properties and applications | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | | 1 | 1 |
| CO3: Practical skills in lithography | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | | 1 | 1 |
| CO4: Identify real-world applications | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | | 1 | 1 |

(Note: The numbers 1, 2, and 3 represent "lightly mapped," "moderately mapped," and "strongly mapped," respectively. Higher numbers indicate a stronger mapping between the Course Objectives and the Program Outcomes/Program Specific Outcomes.)

## RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

| Unit | Course Content |
|---|---|
| Local | Supports local industries in materials development and advanced fabrication methods, fostering innovation. |
| Regional | Augments regional academic and industrial capabilities in materials science, enhancing tech-based development. |
| National | Contributes to the nation's technological progress, especially in material science and advanced manufacturing sectors. |
| Global | Aligns with global material science trends, fostering international collaborations and technology integration. |
| Employability | Equips students for roles in materials science, R&D, manufacturing, and nanotechnology industries. |
| Entrepreneurship | Enables startups in advanced material manufacturing, nanotechnology, and applied research. |
| Skill development | Imparts hands-on skills in material preparation, characterization, and advanced fabrication methods. |

| | |
|---|---|
| Professional ethics | Advocates for responsible material sourcing, ethical research practices, and safe laboratory protocols. |
| Gender | Promotes inclusivity in material science research, fostering equal opportunities regardless of gender. |
| Human values | Emphasizes ethical use of knowledge for societal benefits, considering the broader societal implications and benefits. |
| Environment & sustainability | Stresses eco-friendly practices in material synthesis, promoting sustainability and aligning with SDG goals. |
| SDG | Supporting SDG goals like Goal 3 (Good Health and Well-being), Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 11 (Sustainable Cities and Communities) through diverse applications of nanomaterials. |
| Nep 2020 | Aligns with India's National Education Policy's focus on practical knowledge, research, and innovative applications. |
| Poe/4th IR | Prepares for the Fourth Industrial Revolution with expertise in advanced materials and nanotechnology, essential for emerging tech sectors. |

# Teaching Plan

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| **Week 1** | Introduction to laboratory safety procedures and overview of the experiments. | TB1/CH5 | Class test/presentation/Assignments/Quizzer/ Viva/Project Class test/presentation/Assignments/Quizzer/ |
| **Week 2** | Experiment 1: Preparation of Polystyrene film using solvent evaporation technique. | https://doi.org/10.1021/ma001440d https://pubs.acs.org/doi/abs/10.1021/ma000094x | |
| **Week 3** | Experiment 2: Preparation of magnetite particles using coprecipitation method. | https://www.sciencedirect.com/science/article/abs/pii/S0927775708000721 https://www.sciencedirect.com/science/article/abs/pii/S0304885305005433 https://www.sciencedirect.com/science/article/abs/pii/S0167577X08005740 | |
| **Week 4** | Experiment 3: Preparation of ferrofluid using water and magnetite particles. | https://pubs.acs.org/doi/abs/10.1021/ed076p943 https://www.sciencedirect.com/science/arti | |

| | | | |
|---|---|---|---|
| | | cle/abs/pii/S0304885305011406 | Viva/Project |
| **Week 5** | Experiment 4: Study the stability of magnetite particles in water and vegetable oil. | https://www.sciencedirect.com/science/article/abs/pii/S0021979705004935 https://www.sciencedirect.com/science/article/abs/pii/S0021979705005515 | |
| **Week 6** | Experiment 5: Prepare calcium titanate using solid state reaction method. | https://doi.org/10.1063/1.108974 https://link.springer.com/article/10.1007/s10853-006-0103-y | |
| **Week 7** | Experiment 6: Find the optical band gap of magnetite particles. | https://doi.org/10.1016/j.jallcom.2023.170811 | |
| **Week 8** | Experiment 7: Make pallet of calcium titanate powder, sinter, and polish. | https://fluxana.com/images/Whitepaper/PDF/Whitepaper_Making_Pressed_Pellets.pdf https://patents.google.com/patent/US4260349 https://www.youtube.com/watch?v=o8nok8N5eso | |
| **Week 9** | Experiment 7: Continue pallet preparation and sintering process. | https://fluxana.com/images/Whitepaper/PDF/Whitepaper_Making_Pressed_Pellets.pdf https://patents.google.com/patent/US4260349 https://www.youtube.com/watch?v=o8nok8N5eso | |
| **Week 10** | Experiment 8: Find the density of pallet using Archimedes principle. | https://www.youtube.com/watch?v=4q9Bh48RTxg https://www.youtube.com/watch?v=YpbNyDzpB3A | |
| **Week 11** | Data analysis and interpretation for all experiments. | | |

| | | | |
|---|---|---|---|
| **Week 12** | Finalize reports and presentations for each experiment. | | |
| **Week 13** | Review, discussion, and presentation of experimental findings. | | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Explain the principles of film growth and differentiate between various deposition techniques for thin films. | (i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | • Presentations, quizzers and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Understand the properties and applications of magnetic nanomaterials. | | |
| **3** | Understand the properties and applications of dielectric nanomaterials. | | |
| **4** | Identify, analyze, and relate real-world applications of nanomaterials in areas like molecular electronics, nanoelectronics, catalysis, and photonic devices. | | |

## Semester VIII

| S.No. | COURSE CODE | COURSE TITLE | C |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | SCPH402 | Atomic, and Molecular Physics | 4 |
| 2 | | Research Project-II | 12 |
| Total | | | 16 |

| **SCPH402** | Atomic and Molecular Physics | L | T | P | C |
|---|---|---|---|---|---|
| **Version 1.0** | | 4 | 0 | 0 | 4 |
| **Total Contact Hours** | 50 | | | | |
| **Pre-requisites/Exposure** | | | | | |
| **Co-requisites** | | | | | |

**Course Objectives:**

To understand the fundamental models of the atom: Rutherford scattering experiment, Bohr model, Sommerfeld relativistic model, and quantum (vector) model. Students will learn about the evolution of these models and their significance in explaining atomic spectra and spectral series.

To explore the quantum nature of electrons in atoms and the effect of magnetic fields. Students will learn about quantum numbers, atomic excitation, selection rules, and the Zeeman effect. The exclusion principle and the concept of bosons and fermions will be introduced.

To study the production and characteristics of X-rays. Students will learn about Laue's experiment, Bragg's law, and the classification of X-ray spectra (continuous and characteristic). The Auger effect and X-ray absorption spectra will also be covered.

To gain insights into molecular physics, including molecular bonding, rotational energy levels, vibrational energy levels, and electronic spectra. Students will explore the energy states and selection rules governing molecular transitions, as well as applications like fluorescence and phosphorescence.

**Course Outcomes:**

**CO1** Explain the historical development of atom models and their impact on our understanding of atomic structures and spectral phenomena. Students will be able to describe the key features of Rutherford scattering, Bohr model, Sommerfeld relativistic model, and quantum model.

**CO2** Analyze the quantum nature of electrons and magnetic effects on atoms. Students will be able

to apply quantum numbers, interpret atomic excitation and radiative transitions, and understand the Zeeman effect and spin-orbit coupling.

**CO3** Interpret X-ray production, Bragg's law, and the characteristics of X-ray spectra. Students will understand the Mosley's law, Auger effect, and X-ray absorption spectra.

**CO4** Describe the molecular bonding and electronic transitions in complex molecules. Students will be able to analyze rotational, vibrational, and electronic spectra, including fluorescence and phosphorescence, and understand the determination of internuclear distances.

## CATALOG DESCRIPTION

By the end of the course, students will have gained a comprehensive understanding of atomic and molecular physics, enabling them to analyze and interpret atomic and molecular phenomena, spectral data, and various spectroscopic techniques. They will also develop critical thinking skills, mathematical proficiency, and an appreciation for the quantum nature of matter.

## COURSE CONTENT

**Unit I:** **14 Contact Hours**

Atom Models: Rutherford scattering experiment and the nuclear model of the atom, size of the nucleus, atomic spectra and spectral series.

Bohr model of the atom: energy levels and spectral series, line spectra, discovery of deuterium, correspondence principle, nuclear (reduced) mass and its effect of the atomic spectra: discovery of deuterium, positronium and muonic atom energy levels compared to hydrogen energy levels, critical potentials, atomic excitation, Franck-Hertz experiments. Sommerfeld relativistic model and fine structure of hydrogen.Quantum (Vector) model of the hydrogen atom (no derivation) and quantum numbers, principal quantum number, orbital quantum number, magnetic quantum number, probabilistic electronic orbits (radial and angular), radiative transitions, selection rules.

**Unit II:** **14 Contact Hours**

Effect of Magnetic Fields and Many Electron Atoms: Normal Zeeman effect, gyro-magnetic ratio, Bohr magneton, spin of the electron, spin angular momentum, magnetic dipole moments due to orbital motion and spin of the electron, exclusion principle, Stern-Gerlach experiment. Symmetric and anti-symmetric wave functions, bosons and fermions, atomic shells, subshells and periodic table Spin-orbit coupling, anomalous Zeeman effect, Paschen-Back effect, Stark effect, total angular momentum, LS coupling, j-j coupling, singlet, doublet, triplet, term symbols. Atomic spectra of hydrogen and sodium.

**Unit III:** **14 Contact Hours**

X-Ray Spectra: X-rays: production, Laue's experiment, Bragg's law, X-ray spectra: continuous and characteristic spectra, Mosley's law and X-ray series, Auger effect, X-ray absorption
spectra, absorption edges.

Lasers

Einstein’s A and B coefficients, Metastable states, Spontaneous and Stimulated emissions, Optical Pumping and Population Inversion, Three-Level and Four-Level Lasers, Ruby Laser and He-Ne Laser,

**Unit IV:** **14 Contact Hours**

Molecular Physics: Molecular bond, covalent bond, $H_2^+$ molecular ion, Hydrogen molecule, complex

molecules, hybrid orbitals: ethylene, benzene, Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a Molecule, Vibrational Energy Levels, Selection Rules and Vibration Spectra, Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra, Determination of Internuclear Distance, electronic spectra: fluorescence, phosphorescence.
Raman Effect: Quantum Theory of Raman Effect, Characteristics of Raman Lines, Stoke's and Anti-Stoke's Lines, Complimentary Character of Raman and infrared Spectra;'

**Suggested Text Books**

1. Modern Physics, R. Murugeshan and Kiruthiga Sivaprasath, 17th Ed., S. Chand & Company Pvt. Ltd.
2. Atomic and Molecular Spectra : Laser, Rajkumar, 2020,Knrn

**Advanced Readings**:

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987)
2. Atomic physics by J,B,Rajam& foreword by Louis De Broglie,( S,Chand& Co,, 2007),
3. Atomic Physics by J,H,Fewkes& John Yarwood, Vol, II (Oxford Univ, Press, 1991),
4. Physics of Atoms and Molecules, Bransden and Joachein,
5. Molecular Spectroscopy, Banwell,
6. Optoelectronics by Ghatak and Thyagarajan,Principles of Lasers by Svelto

**Open Educational Resources (OER)**

https://www.geeksforgeeks.org/rutherfords-alpha-scattering-experiment/
http://labs.plantbio.cornell.edu/wayne/pdfs/Fine%20structure.pdf
https://en.wikipedia.org/wiki/Gyromagnetic_ratio#:~:text=In%20physics%2C%20the%20gyromagnetic%20ratio,by%20the%20symbol%20%CE%B3%2C%20gamma.
https://www.youtube.com/watch?v=_1S6KfMzOH8
https://www.radiologymasterclass.co.uk/tutorials/physics/x-ray_physics_production
https://eng.libretexts.org/Bookshelves/Electrical_Engineering/Electro-Optics/Direct_Energy_(Mitofsky)/07%3A_Lamps%2C_LEDs%2C_and_Lasers/7.01%3A_Absorption%2C_Spontaneous_Emission%2C_Stimulated_Emission
https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Book%3A_Quantum_States_of_Atoms_and_Molecules_(Zielinksi_et_al)/07%3A_Rotational_States

**Assessment & Evaluation**

| **Components** | **Quiz/Presentation / Assignment** | **Mid Term Examination** | **Attendance** | **End Term Examination** |
|---|---|---|---|---|
| **Weightage (%)** | **20** | **20** | **10** | **50** |

**Programme And Course Mapping**

Sure, here's the mapping of Course Objectives (CO) with Program Outcomes (PO) and Program Specific Outcomes (PSO) in tabular form:

| CO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| CO 3 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO 4 | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 |

(Note: The mapping is done on a scale of 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped)

**Teaching Plan**

| **Weekly Teaching Plan** | **Topic/Unit No.** | **Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]** | **Teaching-Learning Method** |
|---|---|---|---|
| **Week** 1 | Atom Models: Rutherford scattering experiment and the nuclear model of the atom, size of the nucleus, atomic spectra, and spectral series. | TB1/CH6<br>TB2/CH2<br>https://www.geeksforgeeks.org/rutherfords-alpha-scattering-experiment/ | Class test/presentation/Assignments/Quizzer/ Viva/Project |
| **Week** 2 | Bohr model of the atom: energy levels and spectral series, line spectra, discovery of deuterium, correspondence principle, nuclear (reduced) mass and its effect on atomic spectra, discovery of deuterium, positronium, and muonic atom energy levels compared to hydrogen energy levels, critical potentials, atomic excitation, Franck-Hertz experiments. | TB1/CH6<br>TB2/CH2<br><br>http://labs.plantbio.cornell.edu/wayne/pdfs/Fine%20structure.pdf | Class test/presentation/Assignments/Quizzer/ Viva/Project |

| | | | |
|---|---|---|---|
| **Week** 3 | Sommerfeld relativistic model and fine structure of hydrogen. | TB2/CH2 | |
| **Week** 4 | Quantum (Vector) model of the hydrogen atom (no derivation) and quantum numbers, principal quantum number, orbital quantum number, magnetic quantum number, probabilistic electronic orbits (radial and angular), radiative transitions, selection rules. | TB2/CH3 | |
| **Week** 5 | Effect of Magnetic Fields and Many Electron Atoms: Normal Zeeman effect, gyro-magnetic ratio, Bohr magneton, spin of the electron, spin angular momentum, magnetic dipole moments due to orbital motion and spin of the electron, exclusion principle, Stern-Gerlach experiment. | TB2/CH4<br>https://en.wikipedia.org/wiki/Gyromagnetic_ratio#:~:text=In%20physics%2C%20the%20gyromagnetic%20ratio,by%20the%20symbol%20%CE%B3%2C%20gamma | |
| **Week** 6 | Symmetric and anti-symmetric wave functions, bosons, and fermions, atomic shells, subshells, and periodic table. Spin-orbit coupling, anomalous Zeeman effect, Paschen-Back effect, Stark effect, total angular momentum,. | TB2/CH6<br>TB2/CH12<br>https://www.youtube.com/watch?v=_1S6KfMzOH8 | |
| **Week** 7 | LS coupling, j-j coupling, singlet, doublet, triplet, term symbols. Atomic spectra of hydrogen, sodium. X-Ray Spectra: X-rays: production, Laue's experiment, Bragg's law. | TB1/CH7<br>TB2/CH9 | |
| **Week** 8 | X-ray spectra: continuous and characteristic spectra, Mosley's law and X-ray series, Auger effect, X-ray absorption spectra, absorption edges. | TB1/CH7<br>TB2/CH16<br>https://www.radiologymasterclass.co.uk/tutorials/physics/x-ray_physics_production | |
| **Week** 9 | Lasers: Einstein's A and B coefficients, Metastable states, Spontaneous and Stimulated emissions, Optical Pumping and Population Inversion, Three-Level and Four-Level Lasers, Ruby Laser, and He-Ne Laser. | TB2/CH31<br>TB2/CH32<br>https://eng.libretexts.org/Bookshelves/Electrical_Engineering/Electro- | |

| | | | |
|---|---|---|---|
| | | Optics/Direct_Energy_(Mitofsky)/07%3A_Lamps%2C_LEDs%2C_and_Lasers/7.01%3A_Absorption%2C_Spontaneous_Emission%2C_Stimulated_Emission | |
| **Week** 10 | Molecular Physics: Molecular bond, covalent bond, H2+ molecular ion, Hydrogen molecule, complex molecules, hybrid orbitals: ethylene, benzene. | TB2/CH28 | |
| **Week** 11 | Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a Molecule, Vibrational Energy Levels, Selection Rules, and Vibration Spectra. | TB1/CH23<br><br>https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Book%3A_Quantum_States_of_Atoms_and_Molecules_(Zielinksi_et_al)/07%3A_Rotational_States | |
| **Week** 12 | Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra, Determination of Internuclear Distance, electronic spectra: fluorescence, phosphorescence. | TB1/CH23<br>TB1/CH19 | |
| **Week** 13 | Raman Effect: Quantum Theory of Raman Effect, Characteristics of Raman Lines, Stoke's and Anti-Stoke's Lines, Complimentary Character of Raman and infrared Spectra. | TB1/CH19<br>TB2/CH20 | |

**Facilitating the Achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching Learning Activity | Assessment Task Methods |
|---|---|---|---|
| **1** | Understand the historical | (i) Each topic to be explained | • Presentations and class |

| | | | |
|---|---|---|---|
| | development of atomic models, from Rutherford's scattering experiment to the Quantum (Vector) model, and explain their significance in shaping our understanding of the atom. | with illustrations. (ii) Students to be encouraged to deliver lecture on the relevant topic. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems. | discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations. |
| **2** | Analyze and interpret atomic spectra and spectral series, including line spectra, by applying the principles of Bohr's model, Sommerfeld's relativistic model, and Quantum (Vector) model, as well as the selection rules for radiative transitions. | | |
| **3** | Demonstrate a comprehensive understanding of the interaction of atoms with magnetic fields and the behavior of many-electron atoms, including the Zeeman effect, spin-orbit coupling, Paschen-Back effect, and atomic spectra of hydrogen, sodium, helium, and mercury. | | |
| **4** | Explain the principles of X-ray spectra, including the production of X-rays, Bragg's law, continuous and characteristic spectra, Mosley's law, X-ray absorption spectra, and the Auger effect. Additionally, describe the working principles of lasers, including Einstein’s A and B coefficients, Metastable states, Spontaneous and Stimulated emissions, and the operation of Three-Level and Four-Level Lasers like Ruby Laser and He-Ne Laser. | | |