**KANNUR UNIVERSITY**

**(Abstract)**

M Sc Physics (Advanced Materials) Programme at Dept.of Physics, Swami Ananda Theertha Campus, Payyanur - Revised Scheme & Syllabus - Approved- Implemented w.e f 2023 admission- Orders Issued

**ACADEMIC C SECTION**

ACAD C/ACAD C3/213/2024 Dated: 25.01.2024

Read:-1. UO No ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
2. Circular No dated ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
3. Email dated 04/01/2024 from the Head, Dept. of Physics, Swami Ananda Theertha Campus, Payyanur
4. Letter No KU/DP/HOD/OFFICE/2020(1) dated 01/01/2024 from the Head, Dept of Physics, Swami Ananda Theertha Campus, Payyanur
5. Minutes of the meeting of the Department Council dated 15/09/2023

**ORDER**

1.The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System in the University Teaching Departments/ Schools were implemented w.e.f 2023 admissions vide paper read 1 above

2. As per paper read 2 above, Heads of all Teaching Departments were requested to submit the revised Syllabus in accordance with the approved Regulations along with a copy of the Department Council Minutes.

3. As per paper read 3 above, the Head, Department of Physics, Swami Ananda Theertha Campus, Payyanur submitted the Scheme and Syllabus of M Sc Physics (Advanced Materials) Programme, prepared on the basis of department level workshop conducted, participating subject experts. (Paper read 4).

4. Department Council vide the paper read 5 above approved the aforementioned scheme and syllabus of M Sc Physics (Advanced Materials) Programme to be implemented in the Dept. of Physics at the School of Pure & Applied Physics of the University w.e.f.2023 admission.

5. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1), Chapter lll of Kannur University Act 1996, ***approved the revised Scheme & Syllabus of M Sc Physics (Advanced Materials) Programme and accorded sanction to implement the same in the Department of Physics, , SAT Campus, Payyanur, subject to reporting to the Academic Council.***

6.The revised Scheme and Syllabus of M Sc Physics (Advanced Materials) Programme under CBCSS implemented in the Department of Physics, SAT Campus, Payyanur with effect from 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in)

7. Orders are issued accordingly.

*Sd/-*
**Narayanadas K**
**DEPUTY REGISTRAR (ACAD)**
For REGISTRAR

To:
1. Head, Department of Physics, SAT Campus, Payyanur
2. Convenor, Curriculum Committee

Copy To:
1.PS to VC/ PA to PVC/ PA to R
2. To Examination Branch (through PA to CE)
3. EP IV/ EXC I
4. Computer Programmer
5. Webmanager (to publish in the website)
6. SF/DF/FC

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

Forwarded / By Order
SECTION OFFICER

KANNUR UNIVERSITY

# Regulation, Scheme, and Syllabus

for

M.Sc. PROGRAMME

in

PHYSICS

*(Advanced Materials)*

Outcome Based Education (OBE) Curriculum

w.e.f 2023 Admission

KANNUR UNIVERSITY

Department of Physics

School of Pure and Applied Physics

KANNUR UNIVERSITY

OUTCOME BASED EDUCATION

Department of Physics

**Curriculum Planning Learning- Outcomes-based Approach**

**Nature and Extent of the M.Sc. Physics Programme**

The duration of the M. Sc. Physics (Advanced Materials) programme shall be 2 (two) years. This programme consists of 16 (sixteen) Discipline Specific Core Courses , which includes 11 theory courses, 03 practicum courses, an industrial visit and a project work, 05 (out of 15) Discipline Specific Elective courses, 01 (out of 04) interdisciplinary course, and 01 (out of 02) ability enhancement course. A student can earn 20 credits in 1$^{st}$ semester, 26 credits in 2$^{nd}$ and 23 credits in 3$^{rd}$ semesters, and 16 credits in 4$^{th}$ semester and a total of 85 (eighty-five) credits in the whole programme. Indirect grading patterns with 40% internal and 60% external marks will be followed.

The course structure is as follows:

Types of Courses

**Discipline Specific Core (DSC)**

There are sixteen Discipline Specific Core Courses spread over four semesters in the M. Sc. programme. Out of these, 11 are theory courses- each with 04 credits, 03 are practicum courses- each with 04 credits, an industrial visit with 02 credits, and a project with 04 credits.

**Discipline Specific Elective (DSE)**: There are 15 Disciplinary Specific Elective courses, which belong to category DSE I to DSE V. Students have to take one course each from each category.

**Inter-Disciplinary Course (IDC):**

There are 04 Interdisciplinary courses. Students have to choose one out of four during their second semester.

**Ability Enhancement Courses / Skill Based Courses (AEC)**

There are 02 Ability Enhancement Courses / Skill Based Courses (AEC). Out of these students have to take 01 course in the second semester.

**Multi-Disciplinary Course (MDC):** There are two Multi-Disciplinary courses. Out of these students have to take 01 course in the third semester.

**Value Added Course (VAC):** There is one Value Added course. Students have to take this course in the second semester.

**Dissertation/Project**

In the fourth semester, there will be a project of credit 04 (Four). The project should be very relevant and innovative in nature. It should be aimed to motivate the inquisitive and research aptitude of the students. The type of the project can be decided by the student and the guide (a faculty of the Department or other Department/University/Institution). For the conduction of the project work sufficient span of time will be allotted for the students and its evaluation will be scheduled at the end of the fourth semester. The project will be evaluated by two examiners. The distribution of credits is as follows: 01 for the report, 02 for the presentation of project work done and 01 for comprehensive viva-voce.

**Practical/Tutorial**

The first three semesters will have a course on laboratory practical. A minimum of 16 (sixteen) experiments should be done and recorded in each semester. The practical examination will be conducted at the end of each semester at the Department by two examiners (one internal and the other external). The duration of the examination will be 6 (six) hours.

## PROGRAMME OUTCOMES (POs)

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|---|---|
| PO1 | **Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives. |
| PO2 | **Problem Solving:** Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains. |
| PO3 | **Communication:** Speak, read, write and listen clearly in person and through electronic media in English/Language of the discipline, and make meaning of the world by connecting people, ideas, books, media and technology. |
| PO4 | **Responsible Citizenship:** Demonstrate empathetic social concern, and the ability to act with an informed awareness of issues. |
| PO5 | **Ethics:** Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them. |
| PO6 | **Self-directed and Life-long Learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio- technological changes. |
| PO7 | **Environmental Sustainability and Global Perspective**: Develop an understanding of global standards to foster a legal environment. Learn and practice to critically analyse the legal issues from local, national and international concerns. |
| PO8 | **Network and Collaboration Acquire skills**: To be collaborate and network with scholars in an |

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| | educational institution, professional organizations, research organizations and individuals in India and abroad |

## PROGRAMME SPECIFIC OUTCOMES (PSO)

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|---|---|
| **PSO1** | Use theoretical concepts and principles in physical sciences with specific emphasis on advanced material science to cater to the real-world problems. |
| **PSO2** | Apply mathematical techniques to solve and interpret the results of various physical systems. |
| **PSO3** | Illustrate the methodology required for the execution of physical experiments and analyze the experimental results with the corresponding interpretations. |
| **PSO4** | Develop communication skills to explain the physics concepts to both specialised and non-specialised audiences. |

## PROGRAMME STRUCTURE

**(Total credit: 85)**

**Distribution of Credit, Hours and Marks:**

| Course Code | Course Name | Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| **Part A - Theory Courses** | | | | | | | | | | |
| **First Semester** | | | | | | | | | | |
| **Discipline Specific Core Courses** | | | | | | | | | | |
| MSPHY01DSC01 | MATHEMATICAL PHYSICS I | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY01DSC02 | CLASSICAL MECHANICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY01DSC03 | SOLID STATE PHYSICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY01DSC04 | ELECTRONICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY01DSC05 | PRACTICAL I - ELECTRONICS AND PROGRAMMING | - | 4 | 4 | - | 15 | 15 | 40 | 60 | 100 |
| Total credit for Discipline Specific Core Courses : 20 | | | | | Total teaching hours : 35 | | | | | 500 |
| **Second Semester** | | | | | | | | | | |
| **Discipline Specific Core Courses** | | | | | | | | | | |
| MSPHY02DSC06 | MATHEMATICAL PHYSICS II | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSC07 | QUANTUM MECHANICS I | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

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| MSPHY02DSC08 | ELECTRODYNAMIC THEORY | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSC09 | PRACTICAL II-GENERAL PHYSICS | - | 4 | 4 | - | 15 | 15 | 40 | 60 | 100 |
| Total credit for Discipline Specific Core Courses : 16 | | | | | Total teaching hours : 30 | | | | | 400 |
| **Discipline Specific Elective** | | | | | | | | | | |
| MSPHY02DSE0X | Discipline Specific Elective I | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSE0Y | Discipline Specific Elective II | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| **Discipline Specific Elective I (Offered)** | | | | | | | | | | |
| MSPHY02DSE01 | NUMERICAL TECHNIQUES AND C PROGRAMMING | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSE02 | NUMERICAL TECHNIQUES AND PYTHON PROGRAMMING | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSE03 | NUMERICAL TECHNIQUES AND FORTRAN PROGRAMMING | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| **Discipline Specific Elective II (Offered)** | | | | | | | | | | |
| MSPHY02DSE04 | PHOTOVOLTAIC ENERGY CONVERSION | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSE05 | SIMULATION OF ELECTRONIC CIRCUITS | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY02DSE06 | DENSITY FUNCTIONAL | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |

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|---|---|---|---|---|---|---|---|---|---|---|
| | THEORY | | | | | | | | | |
| Total credit for Discipline Specific Elective courses : 6 | | | | | | Total teaching hours : 10 | | | | 200 |
| **Interdisciplinary Elective** | | | | | | | | | | |
| MSPHY02IDC0X | Interdisciplinary Elective I | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| **Interdisciplinary Elective ( Offered to other department students)** | | | | | | | | | | |
| MSPHY02IDC01 | Digital Signal Processing | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| MSPHY02IDC02 | Environmental Physics | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| MSPHY02IDC03 | Instrumentation Techniques | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| MSPHY02IDC04 | Fundamentals of Meteorology | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| ... | To be obtained from other departments | 2 | - | 2 | 2 | - | 2 | 40 | 60 | 100 |
| Total credit for Interdisciplinary Elective Courses : 2 | | | | | | Total teaching hours : 4 | | | | 100 |
| **Ability Enhancement Courses / Skill Based Courses (To be offered to other department students)** | | | | | | | | | | |
| MSPHY02AEC0X | Ability Enhancement Courses/Skill Based Courses | 1 | 1 | 2 | 2 | 2 | 4 | 40 | 60 | 100 |
| **Ability Enhancement Courses / Skill Based Courses (offered )** | | | | | | | | | | |
| MSPHY02AEC01 | Scientific writing and familiarize LaTeX | 1 | 1 | 2 | 2 | 2 | 4 | 40 | 60 | 100 |
| MSPHY02AEC02 | Operating systems and open software for research | 1 | 1 | 2 | 2 | 2 | 4 | 40 | 60 | 100 |
| ... | To be obtained from other departments | 2 | - | 2 | 2 | 2 | 4 | 40 | 60 | 100 |
| Total credit for Ability Enhancement Courses / Skill Based Courses : 2 | | | | | | Total teaching hours : 4 | | | | 100 |
| **VALUE ADDED COURSE** | | | | | | | | | | |
| MSPHY02VAC01 | Hands-on Techniques for Material Science Research | 1 | 1 | 2* | 2 | 2 | 4 | 40 | 60 | 100* |

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| ** Not to be added to the total marks and credits* | | | | | | | | | | |
| **Third Semester** | | | | | | | | | | |
| **Discipline Specific Core Courses** | | | | | | | | | | |
| MSPHY03DSC10 | QUANTUM MECHANICS II | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY03DSC11 | NUCLEAR PHYSICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY03DSC12 | ATOMIC AND MOLECULAR SPECTROSCOPY | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY03DSC13 | PRACTICAL III-MODERN PHYSICS | - | 4 | 4 | - | 15 | 15 | 40 | 60 | 100 |
| Total credit for Discipline Specific Core Courses : 16 | | | | | | Total teaching hours : 30 | | | | 400 |
| **Discipline Specific Elective** | | | | | | | | | | |
| MSPHY03DSE0X | Discipline Specific Elective III | 3 | | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| **Discipline Specific Elective (Offered)** | | | | | | | | | | |
| MSPHY03DSE07 | FUNCTIONAL MATERIALS AND DEVICES | 3 | | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| MSPHY03DSE08 | SEMICONDUCTING MATERIALS AND DEVICES | 3 | | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| MSPHY03DSE09 | BIOPHYSICS | 3 | | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| Total credit for Discipline Specific Elective courses : 3 | | | | | Total teaching hours : 5 | | | | | 100 |
| **Multi-disciplinary Elective Course (4C)** | | | | | | | | | | |
| MSPHY03MDCX | Multi-disciplinary Elective Course (To be obtained from other departments) | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| **Multi-disciplinary Elective Course (4C) (To be offered to other department students)** | | | | | | | | | | |
| MSPHY03MDC01 | ENERGY PHYSICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

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| MSPHY03MDC02 | LNTRODUCTION TO NANOMATERIALS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| Total credit for Multi-disciplinary Elective course : 4 | | | | | | Total teaching hours : 5 | | | | 100 |
| **Fourth Semester** | | | | | | | | | | |
| **Discipline Specific Core Courses** | | | | | | | | | | |
| MSPHY04DSC14 | STATISTICAL MECHANICS | 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY04DSC15 | INDUSTRIAL VISIT | - | - | 2 | - | - | - | 100 | - | 100 |
| MSPHY04DSC16 | PROJECT | - | - | 4 | - | 15 | 15 | - | 100 | 100 |
| Total credit for Discipline Specific Core Courses : 10 | | | | | | Total teaching hours : 20 | | | | 300 |
| **Disciplinary Elective** | | | | | | | | | | |
| MSPHY04DSE0X | Discipline Specific Elective IV | 3 | - | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| MSPHY04DSE0Y | Disciplinary Elective V | 3 | - | 3 | 5 | -- | 5 | 40 | 60 | 100 |
| **Discipline Specific Elective IV (Offered)** | | | | | | | | | | |
| MSPHY04DSE10 | PARTICLE PHYSICS AND ASTROPHYSICS | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY04DSE11 | GENERAL THEORY OF RELATIVITY | | | | | | | | | |
| MSPHY04DSE12 | QUANTUM FIELD THEORY | | | | | | | | | |
| **Discipline Specific Elective V (Offered)** | | | | | | | | | | |
| MSPHY04DSE13 | THIN FILM TECHNOLOGY | 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |
| MSPHY04DSE14 | LASERS, NONLINEAR OPTICS AND FIBER OPTICS | | | | | | | | | |
| MSPHY04DSE15 | ADVANCED MATERIALS | | | | | | | | | |

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| | CHARACTERIZATION TECHNIQUES | | | | | | | | | |
| Total credit for Discipline Specific Elective courses : 6 | | | | | | Total teaching hours : 10 | | | | 200 |

The following can be Programme Specific:

- L/T = Lecture/Tutorials, P/I= Practical/Interns, CE = Continuous Evaluation, ESE = End Semester Evaluation

| Courses | Credits | Teaching Hours |
|---|---|---|
| **Core**<br>Theory Courses (11x4 )<br>Practicum Courses (03x4)<br>Industrial Visit (01x2)<br>Project (01x4) | <br>44<br>12<br>2<br>4 | <br>55<br>45<br>-<br>15 |
| Discipline Specific Elective Courses (5x3=15) | 15 | 25 |
| Interdisciplinary Elective Courses (1x2) | 2 | 2 |
| Ability Enhancement Courses / Skill Based Courses (1x2) | 2 | 4 |
| Multi-disciplinary Elective Course (4C) (1x4) | 4 | 5 |
| Value Added Course (2C) (1x2)<br>** Not to be added to the total marks and credits* | 2* | 2 |
| Total Credits – 85 | | |
| Total Teaching Hours - 153 | | |

**SEMESTER-I (20C)**

MSPHY01DSC01: MATHEMATICAL PHYSICS I (4C)

MSPHY01DSC02: CLASSICAL MECHANICS (4C)

MSPHY01DSC03: SOLID STATE PHYSICS (4C)

MSPHY01DSC04: ELECTRONICS (4C)

MSPHY01DSC05: Practical I- ELECTRONICS AND PROGRAMMING (4C)

**SEMESTER-II (26C)**

MSPHY02DSC06: MATHEMATICAL PHYSICS II (4C)

MSPHY02DSC07: QUANTUM MECHANICS I (4C)

MSPHY02DSC08: ELECTRODYNAMIC THEORY (4C)

MSPHY02DSC09: PRACTICAL II- GENERAL PHYSICS (4C)

MSPHY02DSE0X: DISCIPLINE SPECIFIC ELECTIVE I (3C)

MSPHY02DSE0Y: DISCIPLINE SPECIFIC ELECTIVE II (3C)

MSPHY02IDC0X: INTERDISCIPLINARY ELECTIVE I (2C)

MSPHY02AEC0X: ABILITY ENHANCEMENT COURSE / SKILL BASED COURSE (2C)

**Discipline Specific Elective I (0X)**

MSPHY02DSE01: NUMERICAL TECHNIQUES AND C PROGRAMMING (3C)

MSPHY02DSE02: NUMERICAL TECHNIQUES AND PYTHON PROGRAMMING (3C)

MSPHY02DSE03: NUMERICAL TECHNIQUES AND FORTRAN PROGRAMMING (3C)

**Discipline Specific Elective II (0Y)**

MSPHY02DSE04: PHOTOVOLTAIC ENERGY CONVERSION (3C)

MSPHY02DSE05: SIMULATION OF ELECTRONIC CIRCUITS (3C)

MSPHY02DSE06: DENSITY FUNCTIONAL THEORY (3C)

**Interdisciplinary Elective I (0X)**

MSPHY02IDC01: DIGITAL SIGNAL PROCESSING (2C)

MSPHY02IDC02: ENVIRONMENTAL PHYSICS (2C)

MSPHY02IDC03: INSTRUMENTATION TECHNIQUES (2C)

MSPHY02IDC04: FUNDAMENTALS OF METEOROLOGY (2C)

**Ability Enhancement Courses / Skill Based Courses I (0X)**

MSPHY02AEC01 : SCIENTIFIC WRITING AND FAMILIARIZE LATEX (2C)

MSPHY01AEC02: OPERATING SYSTEMS AND OPEN SOFTWARE FOR RESEARCH (2C)

**Value Added Course** (*Not to be added to the total marks and credits)*

MSPHY02VAC01: HANDS-ON TECHNIQUES FOR MATERIAL SCIENCE RESEARCH (2C)

**SEMESTER-III (23C)**

MSPHY03DSC10: QUANTUM MECHANICS II (4C)

MSPHY03DSC11: NUCLEAR PHYSICS (4C)

MSPHY03DSC12: ATOMIC AND MOLECULAR SPECTROSCOPY (4C)

MSPHY03DSC13: PRACTICAL III- MODERN PHYSICS (4C)

MSPHY03DSE0X: DISCIPLINE SPECIFIC ELECTIVE III (3C)

MSPHY03MDC0X: MULTI-DISCIPLINARY ELECTIVE COURSE (4C)

**Discipline Specific Elective III (0X)**

MSPHY03DSE07: FUNCTIONAL MATERIALS AND DEVICES (3C)

MSPHY03DSE08: SEMICONDUCTOR MATERIALS AND DEVICES (3C)

MSPHY03DSE09: BIOPHYSICS (3C)

**Multi Disciplinary Elective (0X)**

MSPHY03MDC01: ENERGY PHYSICS (4C)

MSPHY03MDC02: INTRODUCTION TO NANOMATERIALS (4C)

**SEMESTER-IV (16C)**

MSPHY04DSC14: STATISTICAL MECHANICS (4C)

MSPHY04DSC15: INDUSTRIAL VISIT (2C)

MSPHY04DSC16: PROJECT (4C)

MSPHY04DSE0X: DISCIPLINE SPECIFIC ELECTIVE IV (3C)

MSPHY04DSE0Y: DISCIPLINE SPECIFIC ELECTIVE V (3C)

**Discipline Specific Elective IV (0X)**

MSPHY04DSE10: PARTICLE PHYSICS AND ASTROPHYSICS (3C)

MSPHY04DSE11: GENERAL THEORY OF RELATIVITY (3C)

MSPHY04DSE12: QUANTUM FIELD THEORY (3C)

**Discipline Specific Elective V (0Y)**

MSPHY04DSE13: THIN FILM TECHNOLOGY (3C)

MSPHY04DSE14: LASERS, NONLINEAR OPTICS, AND FIBER OPTICS (3C)

MSPHY04DSE15: ADVANCED MATERIALS CHARACTERIZATION TECHNIQUES (3C)

**COURSE OUTCOMES (List for all courses of the Programme)**

**Course Code: MSPHY01DSC01** **Course Name: MATHEMATICAL PHYSICS I**
**Semester: I** **Credits:4**

| | |
|---|---|
| **C01** | Solve physical problems using vector algebra. |
| **C02** | Apply mathematical principles and concepts of matrices to solve practical problems. |
| **C03** | Develop skill to solve problems based on complex variables. |
| **C04** | Analyse and solve linear differential equations. |
| **C05** | Identify the applicability of special functions and polynomials. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 |
| **CO5** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 |

**Course Code: MSPHY01DSC02** **Course Name: CLASSICAL MECHANICS**
**Semester: I** **Credits:4**

| | |
|---|---|
| **C01** | Explain the concepts of Lagrangian and Hamiltonian mechanics and use them to solve problems in mechanics. |
| **C02** | Explain the concepts like generating functions, Poisson brackets and Hamilton-Jacobi equations. |
| **C03** | Analyze the action angle variables concepts to find the frequency of motion of the heavenly bodies. |
| **C04** | Equip the students to apply central force problems and analyze Kepler's laws to find the trajectory of the planetary motion. |
| **C05** | Explain the theory of small oscillations and use Euler's equations of motions for rigid body dynamics. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 | 2 |

**Course Code: MSPHY01DSC03** **Course Name: SOLID STATE PHYSICS**
**Semester: I** **Credits: 4**

| | |
|---|---|
| **C01** | Describe crystal structure, lattice vibrations, and models of thermal properties. |
| **C02** | Explain the concept of band theory of solid and how to classify them. |
| **C03** | Demonstrate the theoretical concepts of semiconductors, dielectric, magnetic, and superconducting materials. |
| **C04** | Describe the concepts of different theories of specific heat capacity. |
| **C05** | Explain the concepts of superconductivity theories and its application. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 2 | 2 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 |

**Course Code: MSPHY01DSC04** **Course Name: ELECTRONICS**
**Semester: I** **Credits: 4**

| | |
|---|---|
| **C01** | Explain the basics of operational amplifiers. |
| **C02** | Design the circuit with operational amplifiers for various applications. |

| | |
|---|---|
| C03 | Explain various components in digital electronic devices. |
| C04 | Explain the architecture of microprocessors and analyze it's working. |
| C05 | Apply theoretical concepts and principles in electronics to cater to the present demands of miniaturization of economically viable devices with very low energy loss. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**Course Code: MSPHY01DSC05 Course Name: PRACTICAL I – ELECTRONICS AND PROGRAMMING**
**Semester: I Credits: 4**

| | |
|---|---|
| C01 | Design and construct various electronic circuits and its validation |
| C02 | Calculate error in various electronics experiments. |
| C03 | Develop programming skills in C/C++ programming. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 2 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 1 | 2 |

**Course Code: MSPHY02DSC06 Course Name: MATHEMATICAL PHYSICS II**
**Semester: II Credits:4**

| | |
|---|---|
| C01 | Develop analytical skills to solve problems in different areas of physics using Fourier series, Fourier and Laplace transforms. |
| C02 | Use Laplace transform to solve differential equations. |
| C03 | Illustrate and apply concepts of group theory in physics problems, which is a prerequisite for deeper understanding of crystallography, particle physics, quantum mechanics and energy bands |

| | |
|---|---|
| | in solids |
| **C04** | Explain how to apply symmetry operations using group theory |
| **C05** | Use the method Green's function to solve non-homogeneous linear differential equations. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO 1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO4 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO5 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY02DSC07** **Course Name: QUANTUM MECHANICS I**
**Semester: II** **Credits: 4**

| | |
|---|---|
| **C01** | Explain the concepts of Linear vector spaces, an imaginary space with infinite degrees of freedom and define the concepts like operators, bra and ket notation for linear vector space and the representation of vectors and operators in matrix form. |
| **C02** | Describe the fundamental postulates of quantum mechanics and the concept of physical observable, and measurement of the complex state and the fact that the physical observables or measurable quantities like energy, angular momentum, linear momentum etc are quantized. |
| **C03** | Explain the basic concepts of quantum dynamics. Describe different pictures like Shroedinger, Heisenberg and the interaction pictures and apply them to solve the Linear Harmonic Oscillator problem and the Hydrogen atom. |
| **C04** | Explain the quantum theory of angular momentum and use angular momentum algebra for physical systems by determining eigenvalues and eigenvectors associated with angular momentum. |
| **C05** | Apply variational methods and the perturbation theory for various physical systems. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY02DSC08** **Course Name: ELECTRODYNAMIC THEORY**

**Semester: II** **Credits: 4**

| | |
|---|---|
| C01 | Demonstrate the linear and nonlinear optical phenomena. |
| C02 | Explain and discuss propagation of electromagnetic waves through different media. |
| C03 | Describe the formulations and relativistic effects in electrodynamics. |
| C04 | Analyze the propagation of electromagnetic waves through waveguides. |
| C05 | Use radiation theory in developing different antennas |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO 7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY02DSC09** **Course Name: PRACTICAL II – GENERAL PHYSICS**

**Semester: II** **Credits: 4**

| | |
|---|---|
| C01 | Explain how to measure various physical quantities. |
| C02 | Calculate error in various advanced physics experiments. |
| C03 | Develop experimental skills |
| C04 | Analyse and point out results of experimental data. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO 2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |

| CO4 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Course Code: MSPHY03DSC10** **Course Name: QUANTUM MECHANICS II**
**Semester: III** **Credits: 4**

| | |
|---|---|
| **C01** | Explain Spin-Orbit interaction and the Born-Oppenheimer approximation in semi classical approach and the quantum theory of spectrum of atoms and molecules. |
| **C02** | Apply the time dependent perturbation theory to calculate the transition probability between different stationary states due to constant perturbation, harmonic perturbation, transition to continuum states etc. |
| **C03** | Illustrate the theory of Scattering. |
| **C04** | Describe the concept of negative energy states, the relativistic wave equation, and the concepts like Bose-Einstein statistics and Fermi-Dirac statistics. |
| **C05** | Explain the concept of field quantization and Lagrangian and Hamiltonian densities. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY03DSC11** **Course Name: NUCLEAR PHYSICS**
**Semester: III** **Credits: 4**

| | |
|---|---|
| **C01** | Describe alpha, beta and gamma decay with corresponding selection rules. |
| **C02** | Explain the basic knowledge of nuclear size, shape, binding energy. etc and also the characteristics of nuclear force. |
| **C03** | Illustrate various nuclear models such as liquid drop model, shell model, collective model and Nilson model. |
| **C04** | Describe the types of nuclear reactions and its applications. |
| **C05** | Apply the theory of nuclear reaction in diagnostic nuclear medicine and therapeutic nuclear medicines. |

### Mapping of Course Outcomes to PSOs/POs

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY03DSC12** **Course Name: ATOMIC AND MOLECULAR SPECTROSCOPY**

**Semester: III** **Credits: 4**

| | |
|---|---|
| C01 | Explain the spectra of hydrogen like atoms, spectra of alkali metals, spectra of many electrons systems |
| C02 | Describe the rotational and vibrational spectra of polyatomic, linear, and symmetric top molecules. And apply the techniques of microwave and infrared spectroscopy to elucidate the structure of molecules |
| C03 | Apply the principle of Raman spectroscopy and its applications |
| C04 | Explain the basic working principle and applications of ESR, NMR, FTIR, and Mossbauer Spectroscopy |
| C05 | Describe the structure determination using IR and Raman Spectroscopy of molecules of type $XY_2$, $XY_3$ and $XY_4$ |

### Mapping of Course Outcomes to PSOs/POs

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY03DSE08** **Course Name: SEMICONDUCTING MATERIALS AND DEVICES**

**Semester: III** **Credits: 3**

| | |
|---|---|
| **C01** | Explain the basic and advanced properties of semiconductor materials. |
| **C02** | Describe the importance of semiconductor materials in various device applications. |
| **C03** | Illustrate working of bipolar junction transistors and field effect transistors on a semiconductor perspective. |
| **C04** | Describe the principle and working of optoelectronic devices such as solar cells, photodetectors, light emitting diodes etc. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 2 |

**Course Code: MSPHY03DSC13 Course Name: PRACTICAL III- MODERN PHYSICS**
**Semester: III Credits: 4**

| | |
|---|---|
| **C01** | Analyse and measure various physical quantities. |
| **C02** | Explain the error analysis in various advanced physics experiments. |
| **C03** | Develop experimental skills |
| **C04** | Analyse and interpret the results of experimental data. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO4 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY03MDC01 Course Name: ENERGY PHYSICS**
**Semester: III Credits: 4**

| | |
|---|---|
| **C01** | Explain energy policy perspectives. |

| | |
|---|---|
| C02 | Describe various technologies for conversion of solar energy resources and illustrate Photovoltaic conversion mechanism. |
| C03 | Use of wind energy conversion. |
| C04 | Describe various modes for ocean energy conversion |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO2 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO3 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO4 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO5 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |

**Course Code: MSPHY03MDC02 Course Name: INTRODUCTION TO NANOMATERIALS**
**Semester: III Credits: 4**

| | |
|---|---|
| C01 | Explain methods of fabricating nanostructures. |
| C02 | Describe different carbon-based nanostructures. |
| C03 | Illustrate the unique properties of nanomaterials to the reduced dimensionality of the material. |
| C04 | Describe tools for properties of nanostructures |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO 3 | PSO 4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |

**Course Code: MSPHY04DSC14 Course Name: STATISTICAL MECHANICS**
**Semester: IV Credits: 4**

| | |
|---|---|
| C01 | Explain the macroscopic phenomena (any natural phenomena) in terms of the microscopic parameters or to bridge the microscopic and macroscopic worlds. |
| C02 | Elucidate the connection between the thermodynamic and statistical parameters. |

| | |
|---|---|
| **C03** | Describe the different ensemble formalism and differentiate micro canonical, canonical and grand canonical ensembles |
| **C04** | Apply statistical mechanics as a tool to solve various physical situations related to classical and quantum mechanical systems with specific examples like Bose Einstein Condensation and black body radiation. |
| **C05** | Explain how a complete theoretical model named Ising model explains the physical phenomenon like phase transition. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO2 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO3 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO4 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| CO5 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 2 |

**Course Code: MSPHY04DSE10 Course Name: PARTICLE PHYSICS AND ASTROPHYSICS**
**Semester: IV Credits: 3**

| | |
|---|---|
| **C01** | Explain the reason why the strong nuclear force is extremely strong and the range of nuclear force is of the order of nuclear radius and explain how the Heisenberg uncertainty relations connecting energy and time is used to deduce the range of nuclear force. |
| **C02** | Describe the concept of resonance and the detection of the resonant particles using resonance production experiment and the resonance formation in experiment. |
| **C03** | Illustrate the conservation laws and intrinsic quantum numbers like baryon, strangeness, isospin, third components of isospin etc. |
| **C04** | Describe the basic building block of matter and their discovery. And explain the theory of the standard model of particle physics. |
| **C05** | Explain the absolute and apparent magnitudes, the Harvard model of the classification of the stars, and the Hertzsprung – Russel Diagram for the representation of the stars. |
| **CO6** | Describe the concepts like interstellar gas, the cooling of the white dwarf, neutron stars and the formation and the detection of the black holes |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO6** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY04DSE13 Course Name: THIN FILM TECHNOLOGY**
**Semester: IV Credits:3**

| | |
|---|---|
| **C01** | Explain the basics of thin films, the theory of thin film formation, and the various factors affecting the structure of thin films. |
| **C02** | Illustrate the different techniques for thin film fabrication like vacuum evaporation, pulsed laser ablation, sputtering, chemical vapor deposition etc. |
| **C03** | Describe how to measure the thickness of thin films and explain the different characterization techniques like XRD, Uv-Vis spectroscopy, SEM, TEM etc and study its theory, construction and working in detail. |
| **C04** | Explain the attenuation mechanisms |
| **C05** | Describe different applications of thin films in technology and daily life. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO2** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO3** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| **CO5** | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY04DSE14 Course Name: LASERS, NONLINEAR OPTICS, AND FIBER OPTICS**
**Semester: IV Credits: 3**

| | |
|---|---|
| **C01** | Explain the basics of LASER, the working principle of different varieties of LASERS, and their applications. |

| | |
|---|---|
| C02 | Describe the propagation of light through optical fiber, the relation between Numerical Aperture and Refractive indices, the types of optical fibers, and the attenuation mechanism. |
| C03 | Illustrate nonlinear optics and explain the Harmonic generation, parametric amplification etc. |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY04DSE15** **Course Name: ADVANCED MATERIALS CHARACTERIZATION TECHNIQUES**

**Semester: IV** **Credits: 3**

| | |
|---|---|
| C01 | Explain the theoretical principles of advanced characterization techniques such as XRD, SEM and TEM |
| C02 | Understand different class materials that can be used for XRD, SEM and TEM and their sample preparations. |
| C03 | Analyze and interpret data obtained from XRD, SEM and TEM |
| C04 | Correlate between material properties and their microstructural features |

**Mapping of Course Outcomes to PSOs/POs**

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 2 |

**Course Code: MSPHY04DSC15** **Course Name: INDUSTRIAL VISIT**
**Semester: IV** **Credits: 2**

| | |
|---|---|
| C01 | Collect data, analyse information, and develop valuable research and analytical skills. |
| C02 | Exposure to various industries, organizations, and professionals, allowing them to explore potential career paths and gain insights into different working environments. |
| C03 | Apply theoretical concepts learned in the classroom to real-world situations, deepening their understanding of the subject matter |

### Mapping of Course Outcomes to PSOs/POs

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 1 |
| CO2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 3 | 1 | 3 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 2 | 3 |

**Course Code: MSPHY04DSC16** **Course Name: PROJECT**
**Semester: IV** **Credits: 4**

| | |
|---|---|
| C01 | Demonstrate the methodology to execute a physical problem or experiment. |
| C02 | Analyse the theoretical/ experimental results. |
| C03 | Explain the physical concepts and write a report on a project of original work. |

### Mapping of Course Outcomes to PSOs/POs

| | PSO 1 | PSO2 | PSO3 | PSO4 | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 3 |

## Course Description

## SEMESTER I

## DISCIPLINE SPECIFIC CORE COURSES

## MSPHY01DSC01: MATHEMATICAL PHYSICS I

**Objectives:** This course is aimed to equip the students with the mathematical techniques used for developing strong background in the basic and advanced level problems. The course describes curvilinear coordinates, complex functions, and applications of complex theory, special functions, tensors and group theory.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Solve physical problems using vector algebra. |
| **C02** | Apply mathematical principles and concepts of matrices to solve practical problems. |
| **C03** | Develop skill to solve problems based on complex variables. |
| **C04** | Analyze and solve linear differential equations. |
| **C05** | Identify the applicability of special functions and polynomials. |

## COURSE CONTENTS

**Module 1**

1.1 Vectors: Rotation of Coordinates, 1.2 Orthogonal Curvilinear Coordinates: Rectangular Cartesian, Circular Cylindrical and Spherical Polar Coordinates,1.3 Differential Vector Operators in Different Coordinate Systems (Gradient, Divergence, Curl & Laplacian Operators), 1.4 Laplace's equation

**Suggested readings specific to the module.**

1.1 Arfken G.B and Weber H.J (Section 1.2), 1.2 Arfken G.B and Weber H.J (Section 2.1)

1.3 Arfken G.B and Weber H.J (Section 2.2), 1.4 Satyaprakash (Section 1.8)

**Module 2**

2.1 Homogeneous and Inhomogeneous Linear Equations, 2.2 Matrices: Basic Properties (Review only), 2.3 Orthogonal, Hermitian and Unitary Matrices, 2.4 Diagonalization of Matrices 2.5 Simultaneous Diagonalization, 2.6 Definition of Tensors, 2.7 Contraction, 2.8 Direct Product, 2.9 Pseudo Tensors, 2.10 Metric Tensors, 2.11 Dual tensors,2.12 Irreducible tensors, 2.13 Kronecker Delta and Levi-Civita Tensors

**Suggested readings specific to the module.**

2.1 Arfken G.B and Weber H.J (Section 3.1), 2.2 Arfken G.B and Weber H.J (Section 3.2), 2.3 Arfken G.B and Weber H.J (Section 3.3 & 3.4), 2.4 Arfken G.B and Weber H.J (Section 3.5), 2.5 Arfken G.B and Weber H.J (Section 3.5), 2.6 Arfken G.B and Weber H.J (Section 2.6), 2.7 Arfken G.B and Weber H.J (Section 2.7), 2.8 Arfken G.B and Weber H.J (Section 2.7), 2.9 Arfken G.B and Weber H.J ( Section 2.9), 2.10 Arfken G.B and Weber H.J (Section 2.10), 2.11 Arfken G.B and Weber H.J ( Section 2.9), 2.12 Arfken G.B and Weber H.J (Section 2.9), 2.13 Arfken G.B and Weber H.J (Section 2.9)

**Module 3**

3.1 Function of Complex Variables: Introduction, 3.2 Analytic Function, 3.3 Cauchy Integral Theorem: Contour Integrals, 3.4 Stoke's Theorem Proof, 3.5 Multiply Connected Regions, 3.6 Cauchy Integral Formula, 3.7 Laurent Expansion: Taylor Expansion and Laurent Series, 3.8 Singularities, 3.9 Calculus of Residues and Applications

**Suggested readings specific to the module.**

3.1 Arfken G.B and Weber H.J (Section 7.1, 7.2 & 7.3), 3.2 Arfken G.B and Weber H.J (Section 6.2), 3.3 Arfken G.B and Weber H.J (Section 6.3), 3.4 Arfken G.B and Weber H.J (Section 6.3), 3.5 Arfken G.B and Weber H.J (Section 6.3), 3.6 Arfken G.B and Weber H.J (Section 6.4), 3.7 Arfken G.B and Weber H.J (Section 6.5), 3.8 Arfken G.B and Weber H.J (Section 6.6), 3.9 Arfken G.B and Weber H.J (Section 7.1)

**Module 4**

4.1 Frobenius Method for Solving Second Order Ordinary Differential Equations with Variable Coefficients, 4.2 Second Solution, 4.3 Self-Adjoint Differential Equations, 4.4 Eigen functions and values, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Completeness of functions, 4.5 Special Functions: Gamma Function, Beta Function, Bessel Functions of First and Second Kinds: Generating Function, Recurrence Relations, Orthogonality, Neumann Function, 4.6 Legendre Polynomials: Generating Function, Recurrence Relations, Rodrigue's Formula, Orthogonality, 4.7 Associated Legendre Polynomials, 4.8 Spherical Harmonics, 4.9 Hermite Polynomials, 4.10 Laguerre Polynomials.

**Suggested readings specific to the module.**

4.1 Arfken G.B and Weber H.J (Section 9.5), 4.2 Arfken G.B and Weber H.J (Section 9.6), 4.3 Arfken G.B and Weber H.J (Section 10.1), 4.4 Arfken G.B and Weber H.J (Section 10.1, 10.2, 10.3 & 10.4), 4.5 Arfken G.B and Weber H.J (Section 8.1, 8.4, 11.1, &11.3), 4.6 Arfken G.B and Weber H.J (Section 12.1,12.2,12.3 & 12.4), 4.7 Arfken G.B and Weber H.J (Section 12.5), 4.8 Arfken G.B and Weber H.J (Section 12.6), 4.9 Arfken G.B and Weber H.J (Section 13.1), 4.10 Arfken G.B and Weber H.J (Section 13.2)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. Arfken G.B and Weber H.J., Mathematical Methods for Physicists, Prism Books (6th edition).
2. Sathyaprakash, Mathematical Physics, S. Chand & Co.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. P. K. Chattopadhyaya, Mathematical Physics, New Age International.
2. L. I. Pipes and L. R. Harvill, Applied Mathematics for Physicists and Engineers, McGraw Hill.
3. R. Courant and D. Hilbert, Methods of Mathematical Physics, Wiley Eastern.

TEACHING LEARNING STRATEGIES

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |

| | |
|---|---|
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

Sample Questions to test Outcomes.

1. Find a unit vector normal to the surface $x^2 + y^2 - 2z = 1$ at the point P(1,1,1)
2. Show that the contraction of a tensor reduces its rank by two.
3. If $u = x^2 - y^2$ , find a corresponding analytic function
4. Evaluate the residue at its pole of the function $\frac{ze^z}{(z-a)^2}$
5. Solve using Frobenius method $\frac{d^2y}{dx^2} + 2x\frac{dy}{dx} + 2y = 0$
6. Prove that $H_n(x) = (-1)^n H_n(-x)$

**MSPHY01DSC02: CLASSICAL MECHANICS**

**Objectives:** This course is aimed to provide basic and advanced concepts in classical mechanics, which acts as a bridge to quantum mechanics and then quantum field theory. The course Starts with D Alembert's principle using Newtonian mechanics utilising dependent coordinates. The theory then modified by using an independent coordinate system to attain Lagrange's equation of motion. Due to restricted degrees of freedom, Lagrange's equation again modified using Legendre transformation to achieve Hamiltonian equations of motion which are 2n first order equations as compared to n second order Lagrange's equations of motion. Hamilton canonical equation of motion again modified to Hamilton-Jacobi equation of motion which is a partial first order differential equation of motion. Even Though partial differential equation is complicated to solve, we can use the techniques of separation of variables to reduce the equation to simple quadrature's which are easy to solve. The paper also gives insight to central force problems, theory of small oscillations, Kepler's problem, Rigid body dynamics and Euler's equations.

| **Credit** | | | **Teaching Hours** | | | **Assessment** | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the concepts of Lagrangian and Hamiltonian mechanics and use them to solve problems in mechanics. |

| | |
|---|---|
| C02 | Explain the concepts like generating functions, Poisson brackets and Hamilton-Jacobi equations. |
| C03 | Analyze the action angle variables concepts to find the frequency of motion of the heavenly bodies. |
| C04 | Equip the students to apply central force problems and analyze Kepler's laws to find the trajectory of the planetary motion. |
| C05 | Explain the theory of small oscillations and use Euler's equations of motions for rigid body dynamics. |

Course outcomes based on revised blooms taxonomy

**COURSE CONTENTS**

**Module 1**

1.1 Constraints and Generalized Coordinates, 1.2 D' Alembert's Principle and Lagrange's Equations, 1.3 Velocity Dependent Potentials, 1.4 Simple Applications, 1.5 Hamilton's Principle

1.6 Elementary Idea of Calculus of Variation, 1.7 Euler-Lagrange Equation, 1.8 Lagrange's Equation from Hamilton's Principle, 1.9 Hamiltonian Function, 1.10 Central Force Problem, 1.11 Scattering in a central force field, 1.12 Equivalent One-Dimensional Problem, 1.13 Classification of Orbits, 1.14 The Kepler Problem, 1.15 Small Oscillations, 1.16 Formulation of the Problem, 1.17 Eigen value Equation, 1.18 Normal Coordinates, 1.19 Free Vibrations of a Linear Triatomic Molecule.

**Suggested readings specific to the module.**

1.1 Goldstein (Section 1.3), 1.2 Goldstein (Section 1.4), 1.3 Goldstein (Section 1.5), 1.4 Goldstein (Section 1.6), 1.5Goldstein (Section 2.1), 1.6 Goldstein (Section 2.2), 1.7 Goldstein (Section 2.3), 1.8 Goldstein (Section 2.3), 1.9 N C Rana & P S Joag (Section 5.2), 1.10 Goldstein (Section 3.1)

1.11 Goldstein (Section 3.10), 1.12 Goldstein (Section 3.3), 1.13 Goldstein (Section 3.3), 1.14 Goldstein (Section 3.7),1.15 Goldstein (Chapter 6), N C Rana & Joag (Section 11.2), 1.16 Goldstein (Section 6.1), 1.17 Goldstein (Section 6.2), 1.18 Goldstein (Section 6.3), 1.19 Goldstein (Section 6.4)

**Module 2**

2.1 Configuration Space and Phase Space, 2.2 Legendre Transformation, 2.3 Hamilton's Canonical Equations, 2.4 Principle of Least Action, 2.5 Applications of Hamilton's Equations: Two-dimensional Isotropic Harmonic Oscillator, Charged Particle in an Electromagnetic Field, 2.6 Canonical Transformations – Examples, 2.7 Infinitesimal Canonical Transformation, 2.8 Poisson Brackets: Properties, 2.9 Equation of Motion in Poisson Bracket Form, 2.10 Angular Momentum Poisson Bracket Relations.

**Suggested readings specific to the module.**

2.1 Goldstein (Section 8.1), 2.2 Goldstein (Section 8.1), 2.3 Kiran C Gupta (Section 4.1), 2.4 Goldstein (Section 8.6), 2.5, 2.6 Goldstein (Section 9.2), 2.7 Goldstein (Section 9.6), 2.8 Goldstein (Section 9.5), 2.9 Goldstein (Section 9.6), 2.10 Goldstein (Section 9.7)

**Module 3**

3.1 Hamilton Jacobi Equation for Hamilton's Principal Function and Hamilton's Characteristic Function, 3.2 Harmonic Oscillator Problem, 3.3 Action Angle Variables, 3.4 Hamilton Jacobi Formulation of Kepler Problem, 3.5 Hamilton Jacobi Equation and Schrodinger Equation.

**Suggested readings specific to the module.**

3.1 Goldstein (Section 10.1, 10.3), 3.2 Goldstein (Section 10.2), 3.3 Goldstein (Section10.6, 10.7), 3.5 N C Rana and P S Joag (Section 10.4.2), 3.5 Kiran C Gupta (Section 10.1)

**Module 4**

4.1 Space Fixed and Body Fixed Systems of Coordinates, 4.2 Description of Rigid Body Motion, 4.3 Direction Cosines, 4.4 Euler Angles, 4.5 Infinitesimal Rotations, 4.6 Rate of Change of a Vector, 4.7 Centrifugal and Coriolis Forces, 4.8 Moment of Inertia Tensor, 4.9 Euler's Equation of Motion.

**Suggested readings specific to the module**

4.1 Goldstein, 4.2 N C Rana and P S Joag (Section 12.3), 4.3 Goldstein (section 4.1), 4.4 Goldstein (section 4.4), 4.5 Goldstein (section 4.8), 4.6 Goldstein (section 4.9), 4.7 N C Rana and P S Joag (section 3.3), 4.8 Goldstein (section 5.3), 4.9 Goldstein (section 5.5)

**Core compulsory reading**

1. Goldstein, Classical Mechanics, third edition, Pearson Education.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill.

**Core suggested reading**

1. R. G. Takwale and P. S. Puranic, Introduction to Classical Mechanics, TMH.
2. V. B. Bhatia, Classical Mechanics, Narosa Publishers.
3. A.J. Griffith, Classical Mechanics, McGraw Hill.
4. Kiran C. Guptha, Classical Mechanics of Particles and Rigid Bodies, New Age International.

TEACHING LEARNING STRATEGIES

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

**Sample Questions to test Outcomes.**

1. Distinguish between generalised coordinates and degrees of freedom.
2. Obtain Euler – Lagrange equations.

3. Explain D'Alembert's principle.
4. Derive the Hamilton equation of motion.
5. Explain by cyclic coordinate? Show that when a coordinate is cyclic in Lagrangian corresponding conjugate momentum is a constant of motion.
6. Obtain Hamiltonian and Hamilton Equation of motion from Lagrangian using Legendre transformation.

## MSPHY01DSC03: SOLID STATE PHYSICS

**Objectives:** To understand and familiarize fundamentals of crystals, lattice vibrations, band theory, and dielectric, magnetic and superconducting properties of materials.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

### COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Describe crystal structure, lattice vibrations, and models of thermal properties. |
| **C02** | Explain the concept of band theory of solid and how to classify them. |
| **C03** | Demonstrate the theoretical concepts of semiconductors, dielectric, magnetic, and superconducting materials. |
| **C04** | Describe the concepts of different theories of specific heat capacity. |
| **C05** | Explain the concepts of superconductivity theories and its application. |

Course outcomes based on revised blooms taxonomy

### COURSE CONTENTS

**Module 1**

1.1 Periodic Arrays of Atoms, 1.2 Symmetry elements of a crystal, Types of space lattices, 1.3 Miller indices, 1.4 Diamond Structure, NaCI Structure, BCC, FCC, HCP structures with examples , 1.5 Fundamental Types of Lattices , 1.6 Index System for Crystal Planes , 1.7 Simple Crystal Structures, Crystal Binding, 1.8 Elementary Ideas of Point Defects and Dislocations, 1.9 Generation and Absorption of X-rays, 1.10 Diffraction of Waves by Crystals, 1.11 Reciprocal Lattice ,Scattered Wave Amplitude, 1.12 Brillouin Zones, 1.13 Fourier Analysis of the Basis – Structure Factor – Atomic Form Factor, 1.14 Vander Waals interaction, Cohesive energy of inert gas crystals
1.15 Madelung interaction, Cohesive energy of ionic crystals, 1.16 Covalent bonding, 1.17 Metallic bonding, 1.18 Hydrogen - bonded crystals.

**Suggested readings specific to the module.**

1.1 C. Kittel (Section 1.1), 1.2 C. Kittel (Section 1.2), 1.3 C. Kittel (Section 1.3), 1.4 C. Kittel (Section 1.2.3, 1.4.1 to 1.4.4), 1.5 C. Kittel (Section 1.2), 1.6 C. Kittel (Section 1.3), 1.7 C. Kittel (Section 1.4), 1.8 Wahab (Section 5.1 to 5.5), 1.9 Wahab (Section 8.2 to 8.4), 1.10 C. Kittel (Section 2.1), 1.11 C. Kittel (Section 2.2), 1.12 C. Kittel (Section

2.3), 1.13 C. Kittel (Section 2.4), 1.14 C. Kittel (Section 3.1), 1.15 C. Kittel (Section 3.2), 1.16 C. Kittel (Section 3.3), 1.17 C. Kittel (Section 3.4), 1.18 C. Kittel (Section 3.5)

**Module 2**

2.1Vibration of Monatomic and Diatomic Linear Lattices, 2.2 Quantization of Elastic Waves, 2.3 Phonon Momentum, 2.4 Phonon Heat Capacity , Density of States in One and Three Dimensions ,2.5 Einstein and Debye Models of specific heat, 2.6 Free Electron Gas, Drude-Lorentz Theory, Electrical Resistivity versus Temperature, 2.7 Free Electron Gas in Three Dimension, 2.8 Fermi Statistics and Fermi Dirac Distribution, 2.9 Heat Capacity of the Free Electron Gas, Electrical Conductivity, 2.10 Hall Effect., 2.11 Energy Spectra of Atoms, Molecules and Solids, Free Electron Model and Origin of Energy Gap, 2.12 Bloch Theorem, 2.13 Kronig-Penney Model, 2.14 Equation of Motion of Electrons in Energy Bands, Holes, Effective Mass, 2.15 Intrinsic Carrier Concentration in Conduction Band and Valence Band, 2.16 Impurity Conductivity, Donor States, Acceptor States.

**Suggested readings specific to the module.**

2.1 C. Kittel (Section 4.1, 4.2), 2.2 C. Kittel (Section 4.3), 2.3 C. Kittel (Section 4.4), 2.4 C. Kittel (Section 5.1), 2.5 C. Kittel (Section 5.1), 2.6 Wahab (Section 10.1), 2.7 Wahab (Section 10.2 to 10.5), 2.8 Wahab (Section 10.6, 10.7), 2.9 Wahab (Section 10.8 to 10.12), 2.10 Wahab (Section 10.15), 2.11 C. Kittel (Section 7.1), 2.12 C. Kittel (Section 7.2), 2.13 C. Kittel (Section 7.3), 2.14 C. Kittel (Section 8.1 to 8.2), 2.15 C. Kittel (Section 8.3), 2.16 C. Kittel (Section 8.4)

**Module 3**

3.1 Superconductivity: Experimental Survey, Occurrence, 3.1.1 Meissner Effect, 3.1.2 Heat Capacity, Energy gap 3.1.3 Isotope Effect 3.2 Theoretical Survey, Thermodynamics of the Superconducting Transition, 3.2.1 London Equation, 3.2.2 Coherence Length, 3.2.3 BCS Theory of Superconductivity (qualitative only),Tunneling, 3.2.4 The Josephson Effect.

**Suggested readings specific to the module.**

3.1 C. Kittel (Section 10.1), 3.2 C. Kittel (Section 10.2)

**Module 4**

4.1 Diamagnetism: Langevin Equation, 4.2 Quantum Theory of Paramagnetism, 4.3 Paramagnetic Susceptibility of Conduction Electrons, 4.4 Ferromagnetic Order: Curie Point and the Exchange Integral, 4.5 Magnons, 4.6 Ferromagnetism, 4.7 Antiferromagnetism – Neel's Model of Antiferromagnetism and Ferrimagnetism, Spin Waves, 4.8 Elementary Ideas of Piezo, Pyro and Ferro Electricity.

**Suggested readings specific to the module.**

4.1 C. Kittel (Section 11.1), 4.2 C. Kittel (Section 11.4), 4.3 C. Kittel (Section 11.6), 4.4 C. Kittel (Section 12.1), 4.5 C. Kittel (Section 12.2), 4.6 C. Kittel (Section 12.6), 4.7 C. Kittel (Section 12.5), 4.8 C. Kittel (Section 12.4), 4.9 Wahab (Section 14.10)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. C. Kittel, Introduction to Solid State Physics, John Willey.

2. Wahab, Solid State Physics, Narosa Publications.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. Omar M. A., Elementary Solid-State Physics, Addison Wesley.

2. A. J. Dekker, Solid State Physics, Addison Wesley Macmillan.

3. Michael P. Marder, Condensed matter Physics, John Willey.

4. Steven H. Simon, The Oxford Solid State Basics

5.Asaroff V., Introduction to Solids, TMH.

**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

**ASSESSMENT RUBRICS**

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

**MSPHY01DSC04: ELECTRONICS**

**Objectives:** This course is aimed to introduce the students with the basic knowledge of analog and digital circuits. The course illustrates the concepts of operational amplifiers and their properties along with various linear and non-linear applications. Also, different kinds of filters are introduced as well as the design criteria of filters for specified bands are also implemented in this course. In addition, this course aims to provide general ideas on various components of digital electronic devices and fundamentals of microprocessors.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the basics of operational amplifiers. |
| **C02** | Design the circuit with operational amplifiers for various applications. |
| **C03** | Explain various components in digital electronic devices. |
| **C04** | Explain the architecture of microprocessors and analyseit's working. |
| **C05** | Apply theoretical concepts and principles in electronics to cater to the present demands of miniaturization of economically viable devices with very low energy loss. |

Course outcomes based on revised bloom's taxonomy

COURSE CONTENTS

**Module 1**

1.1 Introduction to Operational Amplifiers, 1.2 Equivalent Circuit, 1.3 Ideal Characteristics, 1.4 Inverting and Non-Inverting Operational Amplifiers, 1.5 Op-Amp Parameters, 1.6 Concept of Virtual Ground, 1.7 Voltage Gain, 1.8 General Description of Various Stages in Op-Amp, 1.9 Awareness of Type 741 Op-Amp, 1.10 Frequency Response of Op- Amp, 1.11 Open Loop and Closed Loop Frequency Response, 1.12 General Idea of Frequency Compensation, 1.13 Slew Rate and Slew Rate Equation.

**Suggested readings specific to the module.**

1.1 Ramakant A. Gayakward (Section 1.1&1.2), 1.2 Ramakant A. Gayakward (Section 2.4), 1.3 Ramakant A. Gayakward (Section 2.3), 1.4 Ramakant A. Gayakward (Section 2.6), 1.5 Ramakant A. Gayakward (Section 4.2 to 4.11), 1.6 Ramakant A. Gayakward (Section 3.4.2), 1.7 Ramakant A. Gayakward (Section 3.3 & 3.4), 1.8 Ramakant A. Gayakward (Section 1.3), 1.9 Ramakant A. Gayakward (Section 2.2), 1.10 Ramakant A. Gayakward (Section 5.2), 1.11 Ramakant A. Gayakward (Section 5.7& 5.8), 1.12 Ramakant A. Gayakward (Section 5.3 & 5.5), 1.13 Ramakant A. Gayakward (Section 5.10)

**Module 2**

2.1 Linear Applications of Op-Amp: Summing, Averaging and Scaling Amplifiers in the Inverting Mode , 2.2 Summing and Averaging Amplifiers in the Non-Inverting Mode, 2.3 Voltage to Current and Current to Voltage Converters, 2.4 Integrator and Differentiator, 2.5 Non-Linear Op-Amp Circuits (Voltage Comparators, Schmitt Trigger, Logarithmic Amplifiers, Square Wave Generators, Sawtooth Wave Generators, Triangular Wave Generators.), 2.6 Filters (Introduction and General Characteristics , Active Filters and their Designing: First Order and Second Order Low-Pass, High-Pass, Band-Pass, Band-Reject and All Pass Filters.)

**Suggested readings specific to the module.**

2.1 Ramakant A. Gayakward(Section 6.5.1), 2.2 Ramakant A. Gayakward(Section 6.5.2), 2.3 Ramakant A. Gayakward(Section 6.8,9&10), 2.4 Ramakant A. Gayakward(Section 6.12&6.13), 2.5 Ramakant A.

Gayakward(Section 8.2, 8.3, 8.4), Jacob Millman & Chritos C. Halkias(Section 16.14), Ramakant A. Gayakward(Section 7.15, 7.17, and 7.16), 2.6 Ramakant A. Gayakward(Section 7.1 to 7.10)

**Module 3**

3.1 Multiplexer and Demultiplexer, 3.2 Applications of Multiplexers Flip Flops and Timing Circuits, 3.3 Registers: Different Types of Registers and Applications of Shift Registers, 3.4 Counters: Synchronous Counters, Asynchronous Counters, Decade Counters and Mod 8 Ripple Counter, 3.5 A/D and D/A Converters: R-2R Ladder and Successive Approximation Type ADC.

**Suggested readings specific to the module.**

3.1 Malvino&Leach (Section 4.1&4.2), 3.2 Malvino&Leach (Section 8.1 to 8.7), 3.3 Malvino&Leach (Section 9.1 to 9.6), 3.4 Malvino&Leach (Section 10.1 to 10.8), 3.5 Malvino&Leach (Section 11.1 to 11.10) Ramakant A. Gayakward(Section 8.11)

**Module 4**

4.1 Microprocessors, 4.2 Microcomputers, 4.3 8085 Microprocessor, 4.4 Various Operations of Microprocessors, 4.5 Microprocessor Communication and Bus Timing, 4.6 8085 Bus Structure, 4.7 Pin Diagram of 8085 MPU.

**Suggested readings specific to the module.**

4.1 Ramesh Gaonkar (Section 1.1&1.2), 4.2 Ramesh Gaonkar (Section 3.4), 4.3 Ramesh Gaonkar (Section 2.1), 4.4 Ramesh Gaonkar (Section 3.1), 4.5 Ramesh Gaonkar (Section 4.1&4.2), 4.6 Ramesh Gaonkar (Section 4.1), 4.7 Ramesh Gaonkar (Section 4.1)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. K. R. Botker, Integrated Circuits, Khanna Publishers.
3. Ramakant A. Gayakward(Fourth edition), Op-Amps and Linear Integrated Circuits, PearsonEducation.
4. Jacob Millman & Chritos C. Halkias, Integrated Electronics, McGraw Hill.
5. Ramesh Gaonkar (Sixth edition), Microprocessor Architecture, Programming and Application
6. with the 8085, Penram International Publishing Company.
7. Malvino & Leach (Fifth edition), Digital Principles and Applications, TMH.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. A. Anandkumar, Fundamentals of Digital Circuits, Prentice Hall of India.
2. T. L. Floyd, Digital Fundamentals, Prentice Hall.
3. Teaodare F. Bograt Jr., Introduction to Digital Circuits, McGraw Hill.

**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

**Sample Questions to test Outcomes.**

1. Obtain the expressions for the closed loop gain of an inverting and non-inverting op-amps.
2. Define the following terms a) Input offset voltage, b) Common Mode Rejection Ratio,c) Supply Voltage Rejection Ratio, and d) Output voltage swing.
3. Describe Schmitt trigger.
4. In an inverting operational amplifier, the input series resistance is 100kΩ and the feedback resistance is 500kΩ. If the input voltage is 1V, find the exact output voltage.
5. Explain mod-8 ripple counter.
6. Describe the working of a shift register.

**MSPHY01DSC05: PRACTICAL I- ELECTRONICS AND PROGRAMMING**

**Objectives:** Design, construct and verify various electronics circuits and object-oriented C++ programmes to solve numerical problems.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| - | 4 | 4 | - | 15 | 15 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Design and construct various electronic circuits and its validation |
| **C02** | Calculate error in various electronics experiments. |
| **C03** | Develop programming skills in C programming. |

Course outcomes based on revised blooms taxonomy

## COURSE CONTENTS

**List of Experiments:**

**Part I:**

1. FET Characteristics – To determine the characteristics of a JFET and the transistor parameters.
2. Voltage regulation using transistors with feedback (Regulation characteristic with load for different input voltages)
3. Characteristics of silicon-controlled rectifier (half wave and full wave).
4. Two stage RC coupled amplifier (I/O resistance with and without feedback).
5. Negative feedback amplifier (I/O resistance with and without feedback).
6. RC coupled FET amplifier – Common source (frequency response & I/O resistance).
7. Differential amplifier using transistors (Frequency response and CMRR).
8. Amplitude modulation and detection using transistors (modulation index and recovery of modulating signal).
9. Darlington pair amplifier (gain, frequency response and I/O resistance)
10. Wein bridge oscillator using OP AMP (for different frequency distortions due to feedback resistance).
11. Sawtooth generator using transistors (for different frequencies)
12. Miller sweep circuits using OP AMP (for different frequencies)
13. IC 741 Inverting and Non-inverting amplifiers.
14. Schmitt trigger using OP AMP (Trace hysteresis curve, Determination of LTP and UTP).
15. Schmitt trigger using Transistor (Trace hysteresis curve, Determination of LTP and UTP).
16. OPAMP analog simulation and computation – To integrate the given second order differential equation.
17. OPAMP- Analog integration and differentiation (bode plot).
18. OP AMP- Low pass, High pass and band pass filters – frequency response curve.
19. Complementary symmetry amplifier – frequency response, I/O resistance.
20. Binary adders – HA and FA using Nand gates
21. D/A Converter - a) Binary weighted resistors b) R-2R ladder (Four bit or more) – To verify output for different digital inputs.
22. Study of flip-flops (RS and JK using 7400 IC) – To verify the truth tables.
23. IC 555 timer – Astable and Monostable multivibrators.
24. IC555 timers – Bistable multivibrators.
25. IC 555 timer – VCO and Saw tooth wave generators.

**Part II:**

(C/ C++ language or both of them can be used for doing the experiments)

1. Write a program for studying the variation of magnetic field along the axis of a coil
2. Write a program to generate random numbers using a mid-square method and to simulate random walk using these random numbers.
3. Write a program for generating square wave, triangular wave and sawtooth wave using Fourier technique.

4. Write a program to find the roots of a nonlinear equation by Newton-Raphson method.
5. Write a program to interpolate the value of a function using Lagrange's interpolating polynomials.
6. Write programs for numerical integration by using Trapezoidal and Simpson's methods.
7. Write a program to perform matrix addition, subtraction and multiplication and to find the trace and transpose of a matrix.
8. Write a program to find the Taylor series expansion of the given function.
9. Write a program to find the solutions of the first order differential equation using Runge- Kutta method.
10. Write a program to plot the Maxwell-Boltzmann distribution and to prove the equipartition theorem.
11. Write a program to plot Bose-Einstein distribution and to prove the Stefan-Boltzmann law and Wein's displacement law.
12. Write a program to plot Fermi-Dirac distribution.
13. Write a program to draw i-d and $i_1$-$i_2$ curves for $80^0$, $60^0$, $45^0$ and $10^0$ prisms using equations by assuming a refractive index.
14. Write a program to simulate the charged particle in an electromagnetic field.
15. Write a program for least square method for curve fitting.
16. Write a program to study the resonance in an LCR circuit.
17. Write a program to study the trajectory of an ion in Cyclotron Accelerator.
18. Write a program to study the barrier penetration (wave function outside and inside a barrier)
19. Write a program to plot the trajectory of a particle undergoing random motion in one and two dimensions.
20. Write a program to plot momentum versus position for the following systems (i) damped (ii) undamped oscillations

**References:**


1. Paul B. Zbar and Malvine A. P., Basic Electronics, Tata McGraw Hill.
2. Begrat R. Brown J., Experiments for Electronic Devices and Circuits, Merrill International Series.
3. Buchla, Digital Experiments, Merrill International Series.
4. Jain R.P. and Anand M.M.S., Digital Electronics Practice Using ICs, Tata McGraw Hill.
5. Subramanian V. S., Experiments in Electronics, McMillan.
6. Poorna Chandra Rao and Sasikala B., Hand Book of Experiments in Electronics and Communication Engineering.
7. Balagurusamy E, Programming in ANSI C, Tata McGraw Hill.
8. Yashavant Kanetkar, Let Us C, BPB Publications.
9. Balagurusamy E, Numerical Methods, Tata McGraw-Hill


**TEACHING LEARNING STRATEGIES**

- Demonstration, hands-on practice, repetition, and assessment.

MODE OF TRANSACTION

- Seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Record | 5 |
| • Internal tests | 35 |
| • Lab Performance | |

**Sample Questions to test Outcomes.**

1. Design and construct an inverting amplifier using op-amp 741.
2. Design and construct a non-inverting amplifier using op-amp 741.
3. Design and construct a first order low pass filter.
4. Write a program for numerical integration by using the Trapezoidal method.
5. Write a program for numerical integration by using Simpson's method.
6. Write and execute a program to perform Matrix Addition and Subtraction.

**Course Description**

**SEMESTER II**

**DISCIPLINE SPECIFIC CORE COURSES**

**MSPHY02DSC06: MATHEMATICAL PHYSICS II**

**Objectives**: This course is aimed to equip the students with the mathematical skill to solve problems in advanced physics. The course describes Fourier series, Fourier and Laplace transforms, Applications of Fourier and Laplace problems in physical problems, Green's functions for solving differential equations, integral equations, Green's functions, theory of groups and chaos.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

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

| | |
|---|---|
| **C01** | Develop analytical skills to solve problems in different areas of physics using Fourier series, Fourier and Laplace transforms. |
| **C02** | Use Laplace transform to solve differential equations. |
| **C03** | Illustrate and apply concepts of group theory in physics problems, which is a prerequisite for deeper understanding of crystallography, particle physics, quantum mechanics and energy bands in solids |
| **C04** | Explain how to apply symmetry operations using group theory |
| **C05** | Use the method Green's function to solve non-homogeneous linear differential equations. |

## COURSE CONTENTS

**Module 1**

1.1 Fourier Series, 1.2 Introduction and Problems, 1.3 Integral Transforms, 1.4 Properties, 1.5 Fourier Transform and Properties, 1.6 Fourier Transform of Derivatives, 1.7 Convolution Theorem, 1.8 Laplace Transform and Properties, 1.9 Laplace Transform of Derivatives, 1.10 Inverse Laplace Transform.

**Suggested readings specific to the module.**

1.1 Arfken G. B (Section 19), 1.2 Arfken G. B (Section 19.1), 1.3 Arfken G. B (Section 20), 1.4 Arfken G. B (Section 20.3), 1.5 Arfken G. B (Section 20.3), 1.6 Sathyaprakash (Section 10.4), 1.7 Arfken G. B(Section 20.4), 1.8 Arfken G. B(Section 20.7), 1.9 K. F. Riley and Hobson(Section 13.2.1), 1.10 Arfken G. B(Section 20.9)

**Module 2**

2.1 Integral Equations: Transformation of a Differential Equation into an Integral Equation, 2.2 Integral Transforms and Generating Functions, 2.3 Neumann Series, 2.4 Separable Kernel Method, 2.5 Hilbert-Schmidt Theory, 2.6 Green's function: Properties, 2.7 One Dimensional Green's Function, 2.8 Problems, 2.9 Eigen Function Expansion.

**Suggested readings specific to the module.**

2.1 K. F. Riley and Hobson (Section 23.1), Arfken G. B (Section 21), 2.2 K. F. Riley and Hobson (Section 13), 2.3 Arfken G. B(Section 21.3), 2.4 K. F. Riley and Hobson(Section 23.4), 2.5 Arfken G. B(Section 21.4), 2.6 Sathyaprakash(Section 11.8), 2.7 Arfken G. B(Section 10.1), 2.8 Arfken G. B(Section 10.2 ), 2.9 Sathyaprakash(Section 11.11)

**Module 3**

3.1 Groups: General Properties, 3.2 Multiplication Table, 3.3 Consequences, 3.4 Symmetry Group of Square, 3.5 Permutation Group, 3.6 Subgroups, 3.7 Conjugate Elements and Classes, 3.8 Direct Product Groups, 3.9 Isomorphism and Homomorphism, 3.10 Cyclic Group, 3.11 Factor Group, 3.12 Representation of a Group, 3.13

Types of Representation, 3.14 Schur's Lemmas, 3.15 Orthogonality Theorem and Proof, 3.16 Geometrical Interpretation, 3.17 Character of a Representation, 3.18 Character Table, 3.19 Basic Ideas of Continuous Groups, 3.2 SU(2) and SU(3) Groups

**Suggested readings specific to the module.**

3.1 A.W.Joshi(Section 1.1), K. F. Riley and Hobson(Section 28.1), 3.2 A.W.Joshi(Section 1.2), 3.3 A.W.Joshi(Section 1.2), 3.4 A.W.Joshi(Section 1.1.2), 3.5 A.W.Joshi(Section 1.7), 3.6 A.W.Joshi(Section 1.4), 3.7 A.W.Joshi(Section 1.3), 3.8 A.W.Joshi(Section 1.5), 3.9 A.W.Joshi(Section 1.6), 3.10 A.W.Joshi(Section 1.4.1), 3.11 A.W.Joshi(Section 1.4.4), 3.12 Arfken.G.B(Section 17.2), 3.13 Arfken.G.B(Section 17.2), 3.14 A.W.Joshi(Section 3.3), 3.15 A.W.Joshi(Section 3.3), 3.16 A.W.Joshi(Section 3.4), 3.17 A.W.Joshi(Section 3.5), 3.18 A.W.Joshi(Section 3.6), 3.19 Arfken G. B (Section 17.7), 3.2 A.W.Joshi(Section 4.5,Section 4.8)

**Module 4**

4.1 Chaos: Introduction, 4.2 Logistic map, 4.3 Critical Points and Bifurcations, 4.4 Fractals, 4.5 Examples

**Suggested readings specific to the module.**

4.1 Kathleen T. Aligood(Section 3), 4.2 Kathleen T. Aligood(Section 1.6), 4.3 Kathleen T. Aligood(Section 11), 4.4 Kathleen T. Aligood(Section 4), 4.5 Kathleen T. Aligood(Section 4)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)


1. Arfken G. B and Weber H. J., Mathematical Methods for Physicists, Prism Books-Seventh Edition
2. A. W. Joshi, Group Theory for Physicists, Wiley Eastern-Revised fourth edition
3. K. F. Riley and Hobson, Mathematical Methods for Physicists and Engineers, Cambridge-Third edition
4. Kathleen T. Aligood, Tim and James, Chaos: An Introduction to Dynamical Systems, Springer.
5. Michel Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley Eastern


**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)


1. Pipes and Harvil, Applied Mathematics for Physicists and Engineers, McGraw Hill.
2. Sathyaprakash, Mathematical Physics, S. Chand & CO
3. R. Courant and D. Gilbert, Methods of Mathematical Physics, Wiley Eastern.


**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1.Find the Fourier transform of the function f(t) = sin(3t)/t

2.Find the Laplace transform of

3.Explain how Green's function relates to integral equations.

4. Describe Lie groups?

5.Illustrate the representation of a group.

6.Explain the method of plotting logistic maps.

## MSPHY02DSC07: QUANTUM MECHANICS I

**Objectives**: This course on Quantum Mechanics- I give the emphasis on the basic principles, the calculational techniques and the inner consistency and beauty of the theory. For this, a Hibert space formulation of the basic principles and the equation of motion are adopted at the outset. The treatment of linear vector spaces, matrices and the theory of angular momentum is given in a more detailed way. Applications to particular problems are taken up only to illustrate the principle or technique under discussion. Also, the Hilbert space formalism, which provides a unified view of the different formulation of non-relativistic quantum mechanics. Schroedinger's and Heisenberg's formulations appear merely as different representations, analogous respectively to the Hamilton-Jacobi theory and Hamilton's formalism in classical mechanics.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

## COURSE OUTCOMES

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

| | |
|---|---|
| C01 | Explain the concepts of Linear vector spaces, an imaginary space with infinite degrees of freedom and define the concepts like operators, bra and ket notation for linear vector space and the representation of vectors and operators in matrix form. |
| C02 | Describe the fundamental postulates of quantum mechanics and the concept of physical observable, and measurement of the complex state and the fact that the physical observables or measurable quantities like energy, angular momentum, linear momentum etc are quantized. |
| C03 | Explain the basic concepts of quantum dynamics. Describe different pictures like Schrodinger, Heisenberg and the interaction pictures and apply them to solve the Linear Harmonic Oscillator problem and the Hydrogen atom. |
| C04 | Explain the quantum theory of angular momentum and use angular momentum algebra for physical systems by determining eigenvalues and eigenvectors associated with angular momentum. |
| C05 | Apply variational methods and the perturbation theory for various physical systems. |

Course outcomes based on revised blooms taxonomy

## COURSE CONTENTS

**Module 1**

1.1 Linear Vector Space, Ortho Normal Basis, Unitary Space, Hilbert Space, Completeness, Closure Property, 1.2 Operators: Different Types, Commuting operators, 1.3 Dirac Notation, 1.4 Matrix Representation of Vectors, Operators and Bases, Unitary Transformations, Change of Basis, 1.5 Coordinate and Momentum Representation, 1.6 Fundamental Postulates, 1.7 The Equation of Motion, 1.8 Schrodinger Pictures, 1.9 Heisenberg Pictures, 1.10 Interaction pictures, 1.11 Uncertainty Principles, Time Energy Uncertainty Relation, 1.12 Linear Harmonic Oscillator in Schrodinger and Heisenberg Pictures.

**Suggested readings specific to the module.**

1.1 V. K. Thankappan (Section 2.1), 1.2 V. K. Thankappan (Section 2.2), 1.3 V. K. Thankappan (Section 2.3), 1.4 V. K. Thankappan (Section 2.4), 1.5 V. K. Thankappan (Section 2.4A), 1.6 V. K. Thankappan (Section 3.1), 1.7 V. K. Thankappan (Section 4.1), 1.8 V. K. Thankappan (Section 4.1A), 1.9 V. K. Thankappan (Section 4.1B), 1.10 V. K. Thankappan (Section 4.1C), 1.11 V. K. Thankappan (Section 3.2), 1.12 V. K. Thankappan (Section 4.2A)

**Module 2**

2.1 Definition of Angular Momentum, 2.2 Eigen Values and Eigen Vectors, 2.3 Angular Momentum Matrices, Pauli Spin Matrices, 2.4 Orbital Angular Momentum, Angular Momentum and Rotation, Euler Angle, 2.5 Addition of Angular Momentum, Clebsch Gordan Coefficients, Theory of Hydrogen Atom.

**Suggested readings specific to the module.**

2.1 V. K. Thankappan (Section 5.1), 2.2 V. K. Thankappan (Section 5.2), 2.3 V. K. Thankappan (Section 5.3), 2.4 V. K. Thankappan (Section 5.4), 2.5 V. K. Thankappan (Section 5.5)

**Module 3**

3.1 Space-time Symmetries, 3.2 Displacement in Space and Time, 3.3 Space Rotation, 3.4 Space Inversion, 3.5 Time Reversal, 3.6 Identical Particles, Symmetric and Antisymmetric Wave Functions, 3.7 Pauli's Exclusion Principle – Spin and Statistics, 3.8 Two Electron Systems – Helium Atom.

**Suggested readings specific to the module**.

3.1 V. K. Thankappan (Section 6.1 & 6.2), 3.2 V. K. Thankappan (Section 6.2A & 6.2B), 3.3 V. K. Thankappan (Section 6.2C), 3.4 V. K. Thankappan (Section 6.2D), 3.5 V. K. Thankappan (Section 6.2E), 3.6 V. K. Thankappan (Section 9.1), 3.7 V. K. Thankappan (Section 9.2), 3.8 V. K. Thankappan (Section 9.3)

**Module 4**

4.1 Variational Method for Bound States – Ground state of Helium Atom, 4.2 Time Independent Perturbation Theory, 4.3 Non-degenerate Case – Anharmonic Oscillator, 4.4 Degenerate case – Stark and Zeeman Effects in Hydrogen Atom.

**Suggested readings specific to the module.**

4.1 V. K. Thankappan (Section 8.1 & 8.2), 4.2 V. K. Thankappan (Section 8.3), 4.3 V. K. Thankappan (Section 8.3A), 4.4 V. K. Thankappan (Section 8.3B)

**Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks)**

1. V. K. Thankappan, Quantum Mechanics, Wiley Eastern.
2. Ghatak and Lokanathan, Quantum Mechanics, MacMillan
3. Amit Goswami, Quantum Mechanics, Wm. C. Brown Publishers.
4. Bransden and Joachain, Introduction to Quantum Mechanics, ELBS.
5. G. Aruldas, Quantum Mechanics, PHI.

**Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks)**

1. L. L. Schiff, Quantum Mechanics, McGraw Hill.
2. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley.
3. Powell and Crasemann, Quantum Mechanics, Addison Wesley.
4. Stephen Gasirowicz, Quantum Physics, Wiley Eastern.
5. A. Messiah, Quantum Mechanics, John Wiley & Sons.
6. Cohen Tannoudji, C. Diub and Laloe, Quantum Mechanics, Wiley Eastern.

**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1. Explain uncertainty principle.

2. Describe Schroinger interaction picture for harmonic oscillator.

3. Explain Zeeman effect on the basis of quantum mechanics.

4. Explain time independent perturbation theory.

5. Describe the concept of time reversal.

6. List fundamental postulates of quantum mechanics

## MSPHY02DSC08: ELECTRODYNAMIC THEORY

**Objectives**: This course covers linear and non-linear optical phenomenon, propagation of electromagnetic waves, relativistic electrodynamics, radiation and antenna theory.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

### COURSE OUTCOMES

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

| | |
|---|---|
| C01 | Demonstrate the linear and nonlinear optical phenomena. |
| C02 | Explain and discuss propagation of electromagnetic waves through different media. |
| C03 | Describe the formulations and relativistic effects in electrodynamics. |
| C04 | Analyze the propagation of electromagnetic waves through waveguides. |
| C05 | Use radiation theory in developing different antennas |

Course outcomes based on revised blooms taxonomy

### COURSE CONTENTS

**Module 1**

1.1 Electromagnetic waves in linear media, 1.2 The flow of electromagnetic Energy, 1.3 Poynting Vector, 1.4 Boundary conditions, 1.5 Plane monochromatic waves, 1.6 Polarization of plane waves- Linear, Circular, Elliptic etc., 1.7 Reflection and refraction of electromagnetic waves at a plane surface between dielectric media: normal incidence and oblique incidence, 1.8 Brewster's angle, Critical angle ,complex Fresnel coefficients, 1.9 Reflection from a conducting plane , reflection and transmission by a Thin layer interface

**Suggested readings specific to the module**.

1.1 Griffith (Section 9.3), B BLaud (6.1), 1.2 David K Cheng (Section 8.5), 1.3 Griffith (Section 8.1.2), 1.4 Griffith (Section 7.3.6), B BLaud (7.3), 1.5 Griffith (Section 9.2.2), 1.6 Griffith (Section 9.1.4), B BLaud (6.2), 1.7 Griffith (Section 9.3), 1.8 Griffith (Section 9.3), 1.9 Griffith (Section 9.4)

**Module 2**

2.1 Propagation of electromagnetic waves between parallel conducting plates, 2.2 Transverse electromagnetic waves (TEM), Equation for TE Modes, TM or E Mode, TE or M Mode, Properties of the TE and TM Modes, 2.3 TE and TM Mode for rectangular waveguide, 2.4 Resonant cavities, Resonant frequencies for a cylindrical cavity, TM and TE modes, power loses and Q value for a cavity, 2.5 Cylindrical dielectric waveguide

**Suggested readings specific to the module**.

2.1 David K Cheng (Section 10.2.3), 2.2 David K Cheng (Section10.2.1), 2.3 David K Cheng (Section 10.2.4), 2.4 David K Cheng (Section 10.2.7), 2.5 David K Cheng (Section 10.2.6)

**Module 3**

3.1 Radiation from Hertzian dipole, 3.2 Half wave dipole antenna, Quarter wave monopole antenna, 3.3 Antenna characteristics, 3.4 Antenna arrays, 3.5 Effective area and Fris equations

**Suggested readings specific to the module**.

3.1 David K Cheng (Section 11.2), 3.2 David K Cheng (Section 11.4), 3.3 David K Cheng (Section 11.3), 3.4 David K Cheng (Section 11.5), 3.5 David K Cheng (Section 11.7)

**Module 4**

4.1 Geometry of space-time, 4.2 Lorentz Transformation as an orthogonal transformation, 4.3 Covariant form of electromagnetic Equations, 4.4 The electromagnetic field tensor, 4.5 Transformation law for electromagnetic field, 4.6 The field of uniformly moving point charge

**Suggested readings specific to the module**.

4.1 Griffith (Section 12.1.4), 4.2 Griffith (Section 12.1.3), 4.3 Griffith (Section 12.1.4), 4.4 Griffith (Section 12.3.3), 4.5 Griffith (Section 12.3.2), 4.6 Griffith (Section 10.3.2)

Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks)

1. Capri A. Z. and Pant P.V., Introduction to Electromagnetics, Narosa Publications.
2. John R. Reitz, Frederic J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory, Narosa Publications.
3. David.J. Griffiths, Introductions to Electrodynamics,4th Edition, Prentice Hall.
4. Chen. F. F., Introduction to Plasma Physics and Controlled Fusion, Plenum.

**Core Suggested Readings** (Books, Journals, E-sources Websites/ weblinks)

1. Jackson J.D, Classical Electrodynamics, 3rd Edition, John Wiley.
2. David Cheng, Field and Wave Electromagnetics,3rd Edition Pearson Education Asia.
3. Sadik, Electromagnetics.
4. Puri S. P, Classical Electromagnetics, 2nd Edition, Tata McGraw Hill.
5. Laud B. B, Electromagnetics, 3rd Edition, Wiley Eastern.
6. Chopra K. K. and Agarwal G. C., Electromagnetic Theory, 4th Edition, K. Nath and Co., Meerut.

TEACHING LEARNING STRATEGIES

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes**.

1. Explain Maxwell's equations

2. Illustrate the formulations and relativistic effects in electrodynamics.

3. Describe the propagation of electromagnetic waves through waveguides.

4.Explain the concepts of reflection, refraction, and absorption of electromagnetic waves.

5.Describe the behavior of electromagnetic waves in different media, such as air, water, and glass.

6.Describe the behavior of electric fields and magnetic fields in free space.

**MSPHY02DSC09: PRACTICAL II- GENERAL PHYSICS**

**Objectives**: Demonstrate and understand various advanced physics experiments for acquiring fundamental concepts and analyse various experimental data.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| - | 4 | 4 | | 15 | 15 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

**COURSE OUTCOMES**

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

| | |
|---|---|
| C01 | Explain how to measure various physical quantities. |
| C02 | Calculate error in various advanced physics experiments. |
| C03 | Develop experimental skills |
| C04 | Analyse and point out results of experimental data. |

Course outcomes based on revised blooms taxonomy

**COURSE CONTENTS**

List of experiments:

1. Meyer's oscillating disc – To determine the viscosity of the given liquid.
2. Cornu's hyperbolic fringes – Determination of Y, σ and K with Pyrex.
3. Cornu's elliptical fringes – Determination of Y, σ and K with glass.
4. Stefan's constant – Determination of Stefan's constant.
5. Thermocouple – Constants, neutral and inversion temperatures.
6. Lee's disc – K of a liquid/ powder and air using thermocouple.
7. Hysteresis – B-H curves.
8. Maxwell's LC bridge – Determination of R and L of a given coil and C of a condenser.
9. Frequency Bridge – Construction of an oscillator and determination of frequency.
10. Quincke's method – Susceptibility of a liquid at different concentrations.
11. Guoy's method – Susceptibility of glass and aluminium.

12. Cauchy's constants – Determination of Cauchy's constants of sodium light.

13. Laser – Diameter of a thin wire.

14. Laser – Determination of slit width.

15. Laser – Determination of refractive index of a mirror substrate.

16. Laser – Study of intensity distribution and divergence of the beam.

17. Laser – Determination of the pitch of a screw.

18. Fabry-Perot Etalon – $\lambda$ and thickness of air film.

19. Koenig's method – Determination of Y and $\sigma$.

20. Searle's optical interferometer – Determination of Y.

21. Vibrating strip – Determination of mode constants.

22. Expansion of crystal – By optical interference method.

23. Hydrogen spectrum – Series limits and Rydberg constant.

24. Photoelectric effect – Electronic charge and work function of metal

25. Photoelectric cell – Study of elliptically polarized light using deadbeat galvanometer, quarter wave plate, and nicol prism.

26. Fresnel's formula – Verification of Fresnel's formula for the reflection.

**References:**


1.Worsnop B. L. and Flint H. T., Advanced Practical Physics for Students, Methuen & Co.

2.Gupta S. L. and Kumar, Practical Physics, Pragathi Prakashan.

3.Smith E.V., Manual of Experiments in Applied Physics, Butterworth.

4.Dunlap R. A., Experimental Physics, Academic Press.

5.Malacara D., Methods of Experimental Physics, Oxford University Press.


TEACHING LEARNING STRATEGIES

- Demonstration, hands-on practice, repetition, and assessment.

MODE OF TRANSACTION

- Seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Record | 5 |
| ● Internal tests | 35 |

**Sample Questions to test Outcomes.**

1. Determine the viscosity of a given liquid using Mayer's oscillating disc method
2. Determine Young's modulus using Cornu's method.
3. Find out the refractive index of mirror substrate using LASER.
4. Obtain the susceptibility of a given liquid using Quinke's method.
5. Find out mod constant using a vibrating strip.
6. Determine the slit width using LASER.

**MSPHY02DSE0X: DISCIPLINARY SPECIFIC ELECTIVE I (3C)**

**MSPHY02DSE01: NUMERICAL TECHNIQUES AND C PROGRAMMING**
**MSPHY02DSE02: NUMERICAL TECHNIQUES AND PYTHON PROGRAMMING**
**MSPHY02DSE03: NUMERICAL TECHNIQUES AND FORTRAN PROGRAMMING**
(Following questions are applicable to the above mentioned disciplinary elective courses)

Write a program for studying the variation of magnetic field along the axis of a coil

Write a program to generate random numbers using a mid-square method and to simulate random walk using these random numbers.

Write a program for generating square wave, triangular wave and sawtooth wave using Fourier technique.

Write a program to find the roots of a nonlinear equation by Newton-Raphson method.

Write a program to interpolate the value of a function using Lagrange's interpolating polynomials.

Write programs for numerical integration by using Trapezoidal and Simpson's methods.

Write a program to perform matrix addition, subtraction and multiplication and to find the trace and transpose of a matrix.

Write a program to find the Taylor series expansion of the given function.

Write a program to find the solutions of the first order differential equation using Runge- Kutta method.

Write a program to plot the Maxwell-Boltzmann distribution and to prove the equipartition theorem.

Write a program to plot Bose-Einstein distribution and to prove the Stefan-Boltzmann law and Wein's displacement law.

Write a program to plot Fermi-Dirac distribution.

Write a program to draw i-d and $i_1$-$i_2$ curves for $80^0$, $60^0$, $45^0$ and $10^0$ prisms using equations by assuming a refractive index.

Write a program to simulate the charged particle in an electromagnetic field.

Write a program for least square method for curve fitting.

Write a program to study the resonance in an LCR circuit.

Write a program to study the trajectory of an ion in the Cyclotron Accelerator.

Write a program to study the barrier penetration (wave function outside and inside a barrier)

Write a program to plot the trajectory of a particle undergoing random motion in one and two dimensions.

Write a program to plot momentum versus position for the following systems (i) damped (ii) undamped oscillations

**References:**


Paul B. Zbar and Malvine A. P., Basic Electronics, Tata McGraw Hill.

Begrat R. Brown J., Experiments for Electronic Devices and Circuits, Merrill International Series.

Buchla, Digital Experiments, Merrill International Series.

Jain R.P. and Anand M.M.S., Digital Electronics Practice Using ICs, Tata McGraw Hill.

Subramanian V. S., Experiments in Electronics, McMillan.

Poorna Chandra Rao and Sasikala B., Hand Book of Experiments in Electronics and Communication Engineering.

Balagurusamy E, Programming in ANSI C, Tata McGraw Hill.

Yashavant Kanetkar, Let Us C, BPB Publications.

Balagurusamy E, Numerical Methods, Tata McGraw-Hill


## MSPHY02AEC01: SCIENTIFIC WRITING AND FAMILIARIZE LATEX (2C)

**Objectives:** This course is designed to equip students with the skills necessary to communicate scientific research effectively through written documents. The course will cover the principles of scientific writing, including clarity, conciseness, and organization, as well as introduce students to LaTeX, a powerful typesetting system commonly used for scientific documents. Through hands-on exercises and assignments, students will learn how to create well-structured and professionally formatted scientific papers, reports, and presentations.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 1 | 1 | 2 | 1 | 1 | 2 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Describe a strong foundation in scientific writing principles |
| **C02** | Explain the basics of LaTeX and its use in creating scientific documents. |
| **C03** | Describe how to organize and structure scientific papers and reports. |

Course outcomes based on revised blooms taxonomy

## COURSE CONTENTS

**Module 1**

1.1 Introduction to Scientific Writing: Importance and characteristics of scientific writing, 1.2 Clarity and Conciseness: Strategies for clear and concise writing, 1.3 Organization and Structure: Elements of a scientific paper/report (Abstract, Introduction, Methods, Results, Discussion, Conclusion, References), 1.3 LaTeX Introduction: Installing LaTeX and understanding its components, 1.4 Basic document creation and formatting in LaTeX, Mathematics and Equations in LaTeX, Cross-referencing and labels in LaTeX documents.

**Suggested readings specific to the module.**

1.The Craft of Scientific Writing" by Michael Alley - This book provides practical advice on how to write clear, concise, and effective scientific papers. It covers various aspects of scientific writing, including organization, style, and the use of visuals.

2. Scientific Writing and Communication: Papers, Proposals, and Presentations" by Angelika H. Hofmann - This comprehensive guide covers different forms of scientific communication, including papers, proposals, and presentations, with practical tips and examples.

3. "LaTeX: A Document Preparation System" by Leslie Lamport - This is the definitive guide to LaTeX, written by the creator of LaTeX himself. It covers the basics as well as advanced features of LaTeX.

**Module 2**

2.1 Figures and Tables in LaTeX: Including graphics and tables in scientific documents, 2.2 Citations and Bibliography Management: Introduction to BibTeX for handling references, 2.3 Writing Scientific Presentations: Creating slides using LaTeX beamer class

**Suggested readings specific to the module.**

1. "LaTeX: A Document Preparation System" by Leslie Lamport - This is the definitive guide to LaTeX, written by the creator of LaTeX himself. It covers the basics as well as advanced features of LaTeX.

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. "LaTeX: A Document Preparation System" by Leslie Lamport - This is the definitive guide to LaTeX, written by the creator of LaTeX himself. It covers the basics as well as advanced features of LaTeX.
2. The Craft of Scientific Writing" by Michael Alley - This book provides practical advice on how to write clear, concise, and effective scientific papers. It covers various aspects of scientific writing, including organization, style, and the use of visuals.
3. Scientific Writing and Communication: Papers, Proposals, and Presentations" by Angelika H. Hofmann - This comprehensive guide covers different forms of scientific communication, including papers, proposals, and presentations, with practical tips and examples.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. "Getting to Grips with LaTeX" by Andrew Roberts - A beginner-friendly online tutorial that introduces the basics of LaTeX with simple examples and exercises.

2. "Overleaf Documentation" (https://www.overleaf.com/learn) - Overleaf is a popular online LaTeX editor, and their documentation provides a wealth of guides and tutorials to help you get started and master LaTeX.

## MSPHY02AEC02: OPERATING SYSTEMS AND OPEN SOFTWARE'S FOR RESEARCH

### COURSE CONTENTS

**Module 1**

What is an Operating System? Types of Operating Systems (Windows, macOS, Linux, etc.) Key Concepts: Kernel, User Interface, File Systems. Installing and Using a Virtual Machine (e.g., VirtualBox). Introduction to Linux Basic Command Line Navigation File and Directory Operations User and Group Management Permissions and Security.

**Module 2**

What is Open-Source Software? Benefits and Challenges of Open Source, Popular Open-Source Licenses, Introduction to GitHub and Version Control, Text Editors: gedit, nedit, plotting software's: xmgrace/grace, gnuplot, Drawing software's: Gimp, Inkscape, Kolourpaint; Cloud Computing for Research, Octave, FreeCad, JChemPaint, Avogadro, TensorFlow.


1. "Operating System Concepts" by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne
2. "Modern Operating Systems" by Andrew S. Tanenbaum
3. "Linux Kernel Development" by Robert Love


## MSPHY02DSE0Y: DISCIPLINE SPECIFIC ELECTIVE II

### MSPHY02DSE04: PHOTOVOLTAIC ENERGY CONVERSION (3C)

**Course Code:** MSPHY02DSE04 **Course Name: PHOTOVOLTAIC ENERGY CONVERSION**

**Semester: II** **Credits: 3**

| | |
|---|---|
| **C01** | Explain solar cells, its characteristics, and design criteria of solar cells parameters. |
| **C02** | Describe different Thin Film Solar Cell Technologies. |
| **C03** | Explain Solar Photovoltaic Applications |

**MODULE I**

Solar Energy – The Solar Constant – Solar Intensity on Earth's Surface – Direct and Diffuse Radiation – Apparent Motion of Sun – Solar Insolation Data.

**MODULE II**

p-n Junction I-V Relation: Quantitative Analysis – p-n Junction under Illumination: Generation of Photo Voltage (PV) and Light Generated Current – I-V Equation for Solar Cells – Solar Cell Characteristics. Design of Solar Cells: Upper Limit of Solar Cell Parameters: Short Circuit Current, Open Circuit Voltage, Fill Factor and Efficiency – Losses in Solar Cells – Model of Solar Cells – Effect of Series and Shunt Resistance – Solar Radiation and Effect of Temperature on Solar

Cell Efficiency – Solar Cell Design – Design for High Short Circuit Current – Choice of Junction Depth and Orientation – Minimization of Optical Losses and Recombination – Design for High Open Circuit Voltage – Design for High Fill Factor.

**MODULE III**

Thin Film Solar Cell Technologies: Generic Advantages of Thin Film Technologies –Materials for Thin Film Technologies – Thin Film Deposition Techniques – Common Features of Thin Film Technology – Amorphous Si Solar Cell Technology – Cadmium Telluride Solar Cell Technology – Thin Film Crystalline Solar Cells.

**MODULE IV**

Solar Photovoltaic Applications: Solar Photovoltaic (SPV) Modules – SPV from Solar Cells – Series and Parallel Connections – Mismatch in Cell Module – Mismatch in Series Connection – Hot Spots in Modules – Bypass Diode – Mismatch in Parallel Connection – Design and Structure of PV Modules – Number of Solar Cells – Wattage of Modules – PV Module Power Output – I-V Equation for PV Modules – I-V and Power Curves of Module – Effect of Solar Irradiation and Temperature.

**Core Compulsory Readings**

1. S. P. Sukhatme, Solar Energy, Tata McGraw Hill.
2. Chetan Singh Solanki, Solar Photovoltaic: Fundamentals, Technologies and Applications, PHI, 2nd Edn,

**References:**

1. G. Busch and Schade, Lectures on Solid State Physics, Pergamon Press.
2. B. O. Seraphin, Solar energy conversion, Springer.
3. S. R. Das and K. L. Chopra, Thin Film Solar Cells, Springer.
4. Harold J. Hovel, Semiconductors and Semimetals-Vol.II, Academic Press.
5. Martin A. Green, Solar Cells, Prentice Hall Series.
6. Tom Markvart and Luis Castner, Handbook of Solar Cells, Springer.

**MSPHY02DSE05: SIMULATION OF ELECTRONIC CIRCUITS (3C)**

**Module 1:** SPICE: The program and structure. SPICE capabilities. SPICE Commands and compilation. Simulation of AC and DC circuits, PN diodes and transistors. Amplifier circuits.

**Module 2:** Elements of semiconductor physics and operation of PN junction, BJT, JFET and MOSFET and thyristors.

**Module 3:** Modeling of Operational Amplifiers and ICs, and applications Simulation of digital circuits. Other tools for electronic circuit simulation.

**Module 4:** Advanced modeling of semiconductor devices. Practicals involving simulation of example circuits from all topics.

**Core Compulsory Readings**

1.M.H. Rashid, SPICE for Circuits and Electronics, Prentice Hall (1989)

2.S. Sandler, SPICE Circuit Handbook, McGraw Hill (2010)

3.G. Massabrio and P. Antognetti, Semiconductor Device Modeling with Spice, Tata MacGraw Hill (2010)

**MSPHY02DSE06: DENSITY FUNCTIONAL THEORY (3C)**

**Module 1:** introduction Basic concepts of density functional theory. Computational approaches. Basis functions.

**Module 2:** Plane waves and pseudopotentials with applications to the electronic structure of solids. Optical properties.

**Module 3:** Gaussian functions and molecular systems.

Books 1. D. Sholl and J. A. Steckel, Density Functional Theory: A Practical Introduction, Wiley (2009)

2. R. Martin, Electronic Structure: Basic Theory and Practical Methods, Cambridge (2004)

**MSPHY02IDC0X: INTERDISCIPLINARY ELECTIVE (2C)**

**MSPHY02IDC01: DIGITAL SIGNAL PROCESSING**

**Module I**

Basic elements of digital signal Processing: Concept of frequency in continuous time and discrete time signals – Sampling theorem – Discrete time signals.

**Module II**

Discrete time systems –Analysis of Linear time invariant systems –Z transform –Convolution and correlation.

**Core Compulsory Readings**

1. Oppenheim A V and Sehafer R W, “Discrete Time Signal Processing”, Prentice Hall (1989).
2. Proakis J G and Manolakis D G, “Digital Signal Processing”, Pearson Education India.
3. DeFatta D J, Lucas J G and Hodgkiss W S, “Digital Signal Processing”, J Wiley and Sons, Singapore, 1988 4. Sanjit K Mitra “Digital Signal Processing” TMH

**MSPHY02IDC02: ENVIRONMENTAL PHYSICS (2C)**

**Module I**

Basic concepts of light and matter; quantum mechanics (relation between energy, wave length and frequency), Electromagnetic spectrum; black body radiation, Kirchhoff's law, Boltzmann equation, photovoltaic and solar cells; scattering of light, Rayleigh and Mie scattering. Coriolis force, gravitational, centripetal, and centrifugal force

**Module II**

concept of heat transfer, conduction, convection; concept of adiabatic lapse rate (dry and moist adiabatic); concept of heat and work, laws of thermodynamics; concept of entropy and enthalpy. Movement of pollutants in environment (06 lecture s) Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.

**Core Compulsory Readings**

1. Environmental Physics Clare Smith
2. Foundations of Environmental Physics Kyle Forinash
3. Environmental Physics: Sustainable Energy and Climate Change Egbert Boeker

**MSPHY02IDC03: INSTRUMENTATION TECHNIQUES**

**MODULE I**

Nuclear Magnetic Resonance spectroscopy: Principles of H-NMR and C-NMR, chemical shift, factors affecting chemical shift, coupling constant, Spin – spin coupling, relaxation, instrumentation and applications

Mass Spectrometry- Principles, Fragmentation, Ionization techniques – Electron impact, chemical ionization, MALDI, FAB, Analyzers-Time of flight and Quadrupole, instrumentation, applications

**MODULE II**

Thermal Methods of Analysis: Principles, instrumentation and applications of Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC). X-Ray Diffraction Methods: Origin of X-rays, basic aspects of crystals, Xray Crystallography, rotating crystal technique, single crystal diffraction, powder diffraction, structural elucidation and applications.

Core Compulsory Readings

1. "Modern Instrumentation for Scientists and Engineers" by James A. Blackburn
2. "Instrumentation and Control Systems" by William Bolton

**MSPHY02IDC04: FUNDAMENTALS OF METEOROLOGY**

**MODULE 1**

Composition and structure of the atmosphere – Evaporation, condensation, fog, cloud, precipitation and thunderstorm – Thermodynamic principles, properties of dry and moist air, adiabatic processes, hydrostatic stability and instability, parcel method – Radiation: Solar and terrestrial radiation, definitions, laws of radiation, albedo, green-house effect.

**MODULE II**

Local winds: Land and sea breezes, mountain and valley winds, anabatic and katabatic winds, foehn or Chinook – Condensation, precipitation, air masses, front, jet stream, extra-tropical and tropical cyclones, western disturbances, anticyclones, tornado – General Circulation of the Atmosphere: N.E. And S.W. Monsoon, seasons, climate and weather.

**Suggested Books:**

1. Byers: General Meteorology IV edition

2. Cole: Introduction to Meteorology

3. Pettersen: Introduction to Meteorology

4. Banerjee & Upadhyay: Mausam Vigyan

5. Lutgens & Tarbuck: The Atmosphere: An Introduction to Meteorology

6. Das: The Monsoon

**MSPHY02VAC0X: VALUE ADDED COURSE (2C)**

**MSPHY02VAC01: HANDS-ON TECHNIQUES FOR MATERIAL SCIENCE RESEARCH**

**COURSE DESCRIPTION**

The program aims to give a glimpse of hands-on research experience in various branches of experimental physics with particular focus on material characterization techniques.

**COURSE OBJECTIVES**

The course aims to provide extensive understanding and hands-on training in Thin-film deposition, Spin-coating techniques, X-ray diffractometry, UV-Visible spectroscopy, Raman characterization techniques, and electron microscopic

**COURSE CONTENTS**

**MODULE I**

Basics of Fourier analysis, Crystal Systems, X-ray Diffraction, single crystal, powder XRD, Diffraction data analysis. Practical: Instrumentation and hands-on training with sample handling and characterization.

**MODULE II**

Spectroscopy: Basics of Infra-red, UV-Vis spectroscopy, Raman scattering, Photoluminescence. Practical: Sample preparation, Instrument calibration, and hands-on characterization.

**Course Description**

SEMESTER III

DISCIPLINE SPECIFIC CORE COURSES

MSPHY03DSC10: QUANTUM MECHANICS II

**Objectives:** One of the objectives of the course is to give a detailed description of the quantum theory of scattering. The experimental setup to the scattering problem and the concept of partial wave analysis is provided in the course to give an insight into the interaction involving the microscopic word. The theory of scattering is an important tool to peep into the world of microphysics. The topic on time dependent problems deals with the transition probability of the particles to be found in the final state due to time dependent perturbation or disturbance. Also, deals with the probability of transitions due to constant perturbation, transition to continuum and transition probability due to harmonic perturbation. The relativistic wave equation and the failure to consider Klein-Gordon wave equation as the true relativistic wave equation is discussed. The negative energy density and the probability current densities are also discussed in depth. The concept of Dirac equation and the Dirac matrices and the comparison with Pauli spin matrices are also in the scope of the study of the paper.

| **Credit** | | | **Teaching Hours** | | | **Assessment** | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain Spin-Orbit interaction and the Born-Oppenheimer approximation in semi classical approach and the quantum theory of spectrum of atom and molecules. |
| **C02** | Apply the time dependent perturbation theory to calculate the transition probability between different stationary states due to constant perturbation, harmonic perturbation, transition to continuum states etc. |
| **C03** | Illustrate the theory of Scattering. |
| **C04** | Describe the concept of negative energy states, the relativistic wave equation, and the concepts like Bose-Einstein statistics and Fermi-Dirac statistics. |
| **C05** | Explain the concept of field quantization and Lagrangian and Hamiltonian densities. |

Course outcomes based on revised blooms taxonomy

**COURSE CONTENTS**

**Module 1**

1.1 Spin-Orbit Interaction, 1.2 Fine Structure of Hydrogen Atom, 1.3 Anomalous Zeeman Effect, 1.4 The Hartree Equation for Atoms, 1.5 Molecular Structure, 1.6 Born-Oppenheimer Approximation, 1.7 Molecular Orbital Method and Valence Bond Method, 1.8 Hydrogen Molecule Ion and Hydrogen Molecule as Examples.

**Suggested readings specific to the module.**

1.1 V. K. Thankappan(Section 8.3), 1.2 V. K. Thankappan(Section 8.3), 1.3 V. K. Thankappan(Section 8.3), 1.4 V. K. Thankappan(Section 8.3), 1.5 V. K. Thankappan(Section 8.3), 1.6 V. K. Thankappan(Section 8.3), 1.7 V. K. Thankappan(Section 8.3), 1.8 V. K. Thankappan(Section 8.3)

**Module 2**

2.1 Time Dependent Perturbation Theory, 2.1.1 Transition Probability, 2.1.2 Constant Perturbation, 2.1.3 Harmonic Perturbation, 2.2 Interaction of an Atom with an Electromagnetic Field, 2.3 Induced Emission and Absorption, 2.4 Dipole Approximation, 2.5 Born Approximation and Scattering Amplitude., 2.6 Scattering (Scattering Cross Section and Scattering Amplitude, Low Energy Scattering by a Central Potential, Method of Partial Waves, Phase Shifts, Optical Theorem, Scattering by a Square Well Potential, The Born Approximation.)

**Suggested readings specific to the module.**

2.1 V. K. Thankappan(Section 8.4), 2.2 V. K. Thankappan(Section 8.4), 2.3 V. K. Thankappan(Section 8.4), 2.4 V. K. Thankappan(Section 8.4), 2.5 V. K. Thankappan(Section 8.4), 2.6 V. K. Thankappan(Chapter 7)

**Module 3**

3.1 Relativistic Quantum Mechanics: Introduction, 3.2 The First Order Wave Equations , 3.3 Dirac Equations, 3.4 Dirac Matrices, 3.5 Solution of the Free Particle Dirac Equation, 3.6 Spin of the Electron, 3.7 Equation of Continuity, 3.8 Non-relativistic Limit, 3.9 Spin Orbit Coupling, 3.10 Dirac Equation of Hydrogen Atom, 3.11 Covariance of the Dirac Equation, 3.12 Bilinear Covariants, 3.13 The Hole Theory , 3.14 The Weyl Equations for the Neutrino, 3.15 The Second Order Wave Equations ( The Klein-Gordon Equation, Wave Equation of the Photon, Charge Conjugation for Dirac and Klein-Gordon Equations), 3.16 CPT Theorem.

**Suggested readings specific to the module.**

3.1 V. K. Thankappan(Chapter 10), 3.2 V. K. Thankappan(Chapter 10), 3.3 V. K. Thankappan(Chapter 10), 3.4 V. K. Thankappan(Chapter 10), 3.5 V. K. Thankappan(Chapter 10), 3.6 V. K. Thankappan(Chapter 10), 3.7 V. K.

Thankappan(Chapter 10), 3.8 V. K. Thankappan(Chapter 10), 3.9 V. K. Thankappan(Chapter 10), 3.10 V. K. Thankappan(Chapter 10), 3.11 V. K. Thankappan(Chapter 10), 3.12 V. K. Thankappan(Chapter 10), 3.13 V. K. Thankappan(Chapter 10), 3.14 V. K. Thankappan(Chapter 10), 3.15 V. K. Thankappan(Chapter 10), 3.16 V. K. Thankappan(Chapter 10)

**Module 4**

4.1 Quantization of Fields: Principles of Canonical Quantization of Fields, 4.2 Lagrangian Density and Hamiltonian Density, 4.3 Second Quantization of the Schrödinger Wave Field for Bosons and Fermions.

**Suggested readings specific to the module.**

4.1 V. K. Thankappan(Section 11.1), 4.2 V. K. Thankappan(Section 11.2), 4.3 V. K. Thankappan(Section 11.3)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. V. K. Thankappan, Quantum Mechanics, Wiley Eastern.

2. Ghatak and Lokanathan, Quantum Mechanics, MacMillan.

3. Amit Goswami, Quantum Mechanics, Wm. C. Brown Publishers.

4. Bransden and Joachain, Introduction to Quantum Mechanics, ELBS.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. L. L. Schiff, Quantum Mechanics, McGraw Hill.

2. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley.

3. Powell and Crasemann, Quantum Mechanics, Addison Wesley.

4. Stephen Gasirowicz, Quantum Physics, Wiley Eastern.

5. A. Messiah, Quantum Mechanics, John Wiley & Sons.

6. Cohen Tannoubji, C. Diub and Laloe, Quantum Mechanics, Wiley Eastern.

7. Eugence Merzbacher, Quantum Mechanics.

8. P. A. M. Diarc, Principles of Quantum Mechanics.

9. S. N. Biswas, Quantum Mechanics.

**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

**ASSESSMENT RUBRICS**

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1. Describe Spin orbit coupling.
2. Explain the reason why we need Dirac equation.

## MSPHY03DSC11: NUCLEAR PHYSICS

**Objectives:** Nuclear physics is the field of physics that studies atomic nuclei and their constituents and interactions. Nuclear physics is the study of the protons and neutrons at the centre of an atom and the interactions that hold them together in a space just a few femto meters across. The main objective is to provide a basic knowledge about nuclear models, the theory behind the nuclear forces, scattering cross sections, nuclear fission and fusion reactions and their characteristics.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Describe alpha, beta and gamma decay with corresponding selection rules. |
| **C02** | Explain the basic knowledge of nuclear size, shape, binding energy. etc and also the characteristics of nuclear force. |
| **C03** | Illustrate various nuclear models such as liquid drop model, shell model, collective model and Nilson model. |
| **C04** | Describe the types of nuclear reactions and its applications. |
| **C05** | Apply the theory of nuclear reaction in diagnostic nuclear medicine and therapeutic nuclear medicines. |

Course outcomes based on revised blooms taxonomy

## COURSE CONTENTS

**Module 1**

1.1 Radioactive Decay Law, 1.2 Types of Decays, 1.3 Alpha particle Decay, 1.4 Heavy Particle Decay or Cluster Radioactivity, 1.5 Natural Radioactivity, 1.6 Radioactive Dating, 1.7 Gamma Transitions, 1.8 Measurement of Gamma Ray Energy, 1.9 Lifetimes, 1.10 Multipole Moments, 1.11 Decay Rate Formula, 1.12 Selection Rules, 1.13 Angular Correlation and Internal Conversion, 1.14 Beta Decay, 1.15 Simple Theory of Beta Decay, 1.16 Fermi-Kurie Plot, 1.17 Comparative Half-Life, 1.18 Allowed and Forbidden Transitions, 1.19 Selection Rules, 1.20 Parity Violation in Beta Decay, 1.21 Neutrinos. Double Beta Decay (qualitative).

**Suggested readings specific to the module.**

1.1 Kenneth S Krane (Section 6.1), 1.2 Kenneth S Krane (Section 6.5), 1.3 Kenneth S Krane (Section chap.8), 1.4 Kenneth S Krane (Section chap.8), 1.5 Kenneth S Krane (Section 6.6), 1.6 Kenneth S Krane (Section 6.7), 1.7 Kenneth S Krane (Section chap. 10), 1.8 Kenneth S Krane (Section 10.1), 1.9 Kenneth S Krane (Section 10.7), 1.10 Kenneth S Krane (Section 10.2&10.3), 1.11 Kenneth S Krane (Section 10.3), 1.12 Kenneth S Krane (Section 10.4), 1.13 Kenneth S Krane (Section 10.5&10.6), 1.14 Kenneth S Krane (Section chap.9), 1.15 Kenneth S Krane (Section chap.9), 1.16 Kenneth S Krane (Section 9.3), 1.17 Kenneth S Krane (Section 9.5), 1.18 Kenneth S Krane (Section 9.4), 1.19 Kenneth S Krane (Section 9.4), 1.20 Kenneth S Krane (Section 9.9), 1.21 Kenneth S Krane (Section 9.6&9.9)

**Module 2**

2.1 Nuclear Forces: Properties, 2.2 General Characteristic of Nuclear Forces, 2.3 The Deuteron and Two Nucleon Scattering Cross Sections, 2.4 Low Energy n-p Scattering, 2.5 Partial Waves, 2.6 Phase Shift, 2.7 Singlet and Triplet Potentials, 2.8 Effective Range Theory, 2.9 p-p Scattering, 2.10 Yukawa's Theory of Nuclear Forces(qualitative), 2.11 Nuclear Binding Energy, 2.12 Semi Empirical Mass Formula

**Suggested readings specific to the module.**

2.1 Kenneth S Krane (Section 4.4), 2.2 Kenneth S Krane (Section 4.4), 2.3 Kenneth S Krane (Section 4.1,4.2,11.4&11.8), 2.4 Kenneth S Krane (Section chap.4 ), 2.5 Kenneth S Krane (Section 11.8), 2.6 Kenneth S Krane (Section 4.2), 2.7 Kenneth S Krane (Section 4.2&4.3), 2.8 Kenneth S Krane (Section 4.2), 2.9 Kenneth S Krane (Section chap.4), 2.10 Kenneth S Krane (Section 4.5 & 17.1), 2.11 Kenneth S Krane (Section 3.3), 2.12 Kenneth S Krane (Section 3.3)

**Module 3**

3.1 Liquid Drop Model, 3.2 Shell Model, 3.3 Spin Orbit Coupling, 3.4 Spin and Parities of Ground States, 3.5 Magnetic Moments, 3.5 Quadrupole Moment and Schmidt Limits , 3.6 Isospin Symmetry, 3.7 Single Particle Orbits in a Well, 3.8 Collective Model: Rotational and Vibration States, 3.9 Nilsson Model

**Suggested readings specific to the module.**

3.1 Kenneth S Krane (Section 5.2), 3.2 Kenneth S Krane (Section 5.1), 3.3 Kenneth S Krane (Section 5.1), 3.4 Kenneth S Krane (Section 5.1), 3.5 Kenneth S Krane (Section 5.1&16.2), 3.6 Kenneth S Krane (Section 11.3), 3.7 Kenneth S Krane (Section chap.5), 3.8 Kenneth S Krane (Section 5.2&5.3), 3.9 Kenneth S Krane (Section5.3)

**Module 4**

4.1 Nuclear Fission, 4.2 Characteristics of Fission, 4.3 Mass Distribution of Fission Fragments, 4.4 Energy in Fission, 4.5 Neutrons Released in Fission, 4.6 Cross Sections, 4.7 Fission Reactors Operating with Natural Uranium as Fuel, 4.8 Fission and Thermonuclear Energy, 4.9 Breeder Reactor, 4.10 Controlled Fusion Energy, 4.11 Qualitative Treatment of Applications of Nuclear Fusion, 4.12 Diagnostic Nuclear Medicine and Therapeutic Nuclear Medicines.

**Suggested readings specific to the module**

4.1 Kenneth S Krane (Section 13.1), 4.2 Kenneth S Krane (Section 13.2), 4.3 Kenneth S Krane (Section 13.2), 4.4 Kenneth S Krane (Section 13.3), 4.5 Kenneth S Krane (Section 13.2), 4.6 Kenneth S Krane (Section 13.2), 4.7 Kenneth S Krane (Section 13.6 &13.8), 4.8 Kenneth S Krane (Section 13.3& 13.5), 4.9 Kenneth S Krane (Section

13.6), 4.10 Kenneth S Krane (Section 14.4), 4.11 Kenneth S Krane (Section 14.4), 4.12 Kenneth S Krane (Section 20.4 &20.5)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)


1. Kenneth S. Krane, Introduction to Nuclear Physics, John Wiley.

2. J. S. Lilley, Nuclear Physics: Principles and Applications, John Wiley.

3. G. F. Knoll, Nuclear Radiation Detector and Measurement, Wiley.

4. Herald A. Engel, Introduction to Nuclear Physics, Addison Wesely.

5. S. B. Patel, An Introduction to Nuclear Physics, New Age International.


**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)


1.Samuel M. Wong, Introductory Nuclear Physics, Prentice Hall of India.
2.S. G. Nilsson & I. Ragnarsson, Shapes and Shells and Nuclear Structure, Cambridge University Press.
3.Marmier& Sheldon, Physics of Nuclei and Particles, Vol. II, Academic Press.
4.Burcharm& Jones, Nuclear and Particle Physics, Longman.
5.Roy R. K. and Nigam P. P., Nuclear Physics, Tata McGraw Hill.
6.Cohen B. L., Concepts of Nuclear Physics, Tata McGraw Hill.


TEACHING LEARNING STRATEGIES

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1. Explain natural radioactivity.
2. Describe Yukawa's theory of nuclear reaction.
3. List the drawback of the liquid drop model of the nucleus.
4. Explain the basic working principle of ESR.
5. Distinguish nuclear Fission and Fusion.
6. Describe the characteristics of nuclear Fission.

## MSPHY03DSC12: ATOMIC AND MOLECULAR SPECTROSCOPY

**Objectives:** Spectroscopy is the study of the interaction between matter and electromagnetic radiation via atomic and molecular spectroscopy. This course provides an introductory idea to the postgraduate students about the spectra of hydrogen like atoms, alkali spectra and spectra of many electron systems. It also gives insightful knowledge about the changes in the spectra of different atoms in presence of an external field as well as the change in the energy levels of these atoms due to the different types of magnetic interactions. The present contents of this course also provide the basic physical properties like different types of spectra (electronic, rotational and vibration) of different molecules with different atoms. The main topics included in the course structure are atomic spectra, coupling schemes, normal Zeeman effect, anomalous Zeeman effect, Paschen-Back effect, rotation and vibration spectra of molecules, infrared spectroscopy, Raman spectroscopy, NMR spectroscopy, ESR spectroscopy etc.

| **Credit** | | | **Teaching Hours** | | | **Assessment** | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the spectra of hydrogen like atoms, spectra of alkali metals, spectra of many electron systems |
| **C02** | Describe the rotational and vibrational spectra of polyatomic, linear, and symmetric top molecules. And apply the techniques of microwave and infrared spectroscopy to elucidate the structure of molecules |

| | |
|---|---|
| **C03** | Apply the principle of Raman spectroscopy and its applications |
| **C04** | Explain the basic working principle and applications of ESR, NMR, FTIR, and Mossbauer Spectroscopy |
| **C05** | Describe thestructure determination using IR and Raman Spectroscopy of molecules of type $XY_2$, $XY_3$ and $XY_4$ |

Course outcomes based on revised blooms taxonomy

## COURSE CONTENTS

**Module 1**

1.1 Spectra of Hydrogen Like Ions, 1.2 Alkali Spectra, 1.3 Many Electron Systems, 1.4 L-S and j-j Coupling, 1.5 Space Quantization, 1.6 Stern-Gerlach Experiment, 1.7 Zeeman Effect, 1.8 Normal and Anomalous Zeeman Effect, 1.9 Lande-g Formula, 1.10 Paschen-Back effect, 1.11 Stark Effect, 1.12 Hyperfine Structure of Spectral Lines.

**Suggested readings specific to the module.**

1.1 C. N. Banwell (Section 5.3.2), 1.2 G. Aruldas (Section 3.8) , 1.3 C. N. Banwell (Section 5.3), 1.4 G. Aruldas (Section 3.9) , 1.5 G. Aruldas (Section 2.2.6), 1.6 Nptel video (https://www.youtube.com/watch?v=d0TMs-FpcW0), 1.7 G. Aruldas (Section 3.12), 1.8 G. Aruldas (Section 3.12,3.13), 1.9 G. Aruldas (Section 3.13.1), 1.10 G. Aruldas (Section 3.14), 1.11 G. Aruldas (Section 3.16), 1.12 G. Aruldas (Section 3.15)

**Module 2**

2.1 Review of Rotation and Vibration Spectra, 2.2 Breakdown of Born-Oppenheimer Approximation, 2.3 Vibrations of Polyatomic Molecules, 2.4 Rotational and Vibrational Spectra of Polyatomic Molecules, 2.5 Linear and Symmetric Top Molecules, 2.6 FTIR, 2.7 Electronic Spectra of Diatomic Molecules, 2.8 Vibrational Coarse Structure, 2.9 Progressions, 2.10 Franck-Condon Principle, 2.11 Rotational Fine Structure of Electronic Vibrational Transitions, 2.12 The Fortrat Diagram, 2.13 Dissociation and Predissociation.

**Suggested readings specific to the module.**

2.1 C. N. Banwell (Chapter 2 and 3), 2.2 C. N. Banwell (Section 3.4), 2.3 G. Aruldas (Section 7.7), 2.4 G. Aruldas (Section 7.11), 2.5 G. Aruldas (Section 7.11.1, 7.11.3), 2.6 G. Aruldas (Section 7.18), 2.7 C. N. Banwell (Section 6.1), 2.8 G. Aruldas (Section 9.2), 2.9 G. Aruldas (Section 9.4), 2.10 G. Aruldas (Section 9.6), 2.11 G. Aruldas (Section 9.7), 2.12 G. Aruldas (Section 9.8), 2.13 G. Aruldas (Section 9.9, 9.10)

**Module 3**

3.1 Classical Theory of Raman Effect, 3.2 Pure Rotational Raman Spectra of Linear and Symmetric Top Molecules, 3.3 Vibration Raman Spectra, 3.4 Raman Activity of Vibrations, 3.5 Rules of Mutual Exclusion, 3.6 Example of $H_2O$ and $CO_2$ ,3.7 Vibration Raman Spectra of Symmetric Top Molecules, 3.8 Structure Determination Using IR and Raman Spectroscopy, 3.9 Molecules of type $XY_2$, $XY_3$ and $XY_4$.

**Suggested readings specific to the module**

3.1 C. N. Banwell (Section 4.1.2), 3.2 G. Aruldas (Section 8.3), 3.3 G. Aruldas (Section 8.4), 3.4 C. N. Banwell (Section 4.3), 3.5 G. Aruldas (Section 8.5), 3.6 C. N. Banwell (Section 4.3), 3.7 G. Aruldas (Section 8.4), 3.8 G.Aruldas (Section 8.12), 3.9 G. Aruldas (Section 8.12.1, 8.12.2, 8.12.3)

**Module 4**

4.1 Interaction Between Nuclear Spin and Magnetic Field, 4.2 Larmor Precession, 4.3 Resonance Condition, 4.4 Chemical Shift, 4.5 Example of $CH_3OH$, 4.6 NMR Spectrometer, 4.7 Application in Medicine (MRI), 4.8 Principle of ESR, 4.9 Principles of Mossbauer Spectroscopy, 4.10 Doppler Shift, 4.11 Mossbauer Spectrometer, 4.12 Applications of Mossbauer Spectroscopy.

**Suggested readings specific to the module.**

4.1 G. Aruldas (Section 10.1), 4.2 C. N. Banwell (Section 7.1.4), 4.3 G. Aruldas (Section 10.2), 4.4 G. Aruldas (Section 10.8), 4.5 G. Aruldas (Section 10.8), 4.6 C. N. Banwell (Section 7.2), 4.7 C. N. Banwell (Section 8.3.3), 4.8 C. N. Banwell (Section 7.5), 4.9 C. N. Banwell (Section 9.1), 4.10 C. N. Banwell (Section 9.1), 4.11 C. N. Banwell (Section 9.1), 4.12 C. N. Banwell (Section 9.2)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. C. N. Banwell & E. M. Mc Cash, Fundamentals of Molecular Spectroscopy, TMH. ($4^{th}$ edition)
2. G. Aruldas, Molecular Structure and Spectroscopy, Prentice Hall. ($2^{nd}$ edition)

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. B. P. Straughn & S. Walker, Spectroscopy-Vol. I& II, Chapman & Hall.
2. G. Herzberg, Molecular Spectra and Molecular Structure Vol I, II & III, VAN Nostrand Company.
3. H. E. White, Introduction to Atomic Spectra, McGraw Hill.

TEACHING LEARNING STRATEGIES

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1. Explain Raman effect
2. Distinguish between Zeeman effect and Stark Effect
3. Explain the spectra of Hydrogen like atoms
4. Distinguish between NMR and ESR
5. Discuss the theory of the vibrational spectrum of a molecule.
6. Explain rotational Raman spectra of rigid diatomic molecules.

**MSPHY03DSC13: PRACTICAL III -MODERN PHYSICS**

**Objectives:** Demonstrate and understand various advanced physics experiments for acquiring fundamental concepts and analyse various experimental data.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| - | 4 | 4 | | 15 | 15 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Analyse and measure various physical quantities. |
| **C02** | Explain the error analysis in various advanced physics experiments. |

| | |
|---|---|
| **C03** | Develop experimental skills |
| **C04** | Analyse and interpret the results of experimental data. |

**COURSE CONTENTS**

**List of Experiment:**

1. G.M counter – Plateau and statistics of counting, operating voltage and to verify the distribution law satisfied by the radioactive decay.
2. Absorption coefficient of "gamma" rays – To determine the absorption coefficient of a given material for CS 137 gamma rays using the GM counter.
3. Absorption coefficient of "beta" rays – To determine the Absorption coefficient of a given material for beta ray source using the GM counter.
4. Feather analysis – To determine the end point energy of beta particles from the given source by feather analysis method.
5. Scintillation Counter – To calibrate the given gamma ray (Scintillation) spectrometer using standard gamma ray source and to determine the energy of an unknown source.

**2.** Compton scattering – To verify the theoretical expression for the energy of the Compton scattered gamma rays at a given angle using a scintillation gamma spectrometer and to determine the rest mass energy of the electron.

**3.** Hydrogen spectrum – To photograph the spectrum and hence to determine the Rydberg constant.

**4.** Absorption spectrum of $KMnO_4$ – To photograph the absorption spectrum and to determine the wavelengths of the absorption band.

**5.** Absorption spectrum of Iodine – To photograph the iodine spectrum and to determine the dissociation energy.

**6.** Vibration bands of $Al_2O_3$ – To photograph the emission of $Al_2O_3$ spectrum and to identify the band heads.

**7.** Nuclear magnetic resonance – To determine g-factor.

**8.** Carbon arc – To photograph the emission spectrum and to identify the spectral lines of iron, copper and potassium.

**9.** Hall Effect in semiconductors – To determine the carrier concentration in the given specimen of semiconductor material.

**10.** Determination of band gap energy in silicon.

**11.** Determination of band gap energy in germanium.

**12.** Zener voltage characteristics at low and ambient temperatures – To study the variation of Zener voltage of a given diode with temperature.

**13.** Ultrasonic Interferometer – To determine the velocity of ultrasonic waves in the given liquids.

**14.** Thin films – To determine the electrical conductivity, reflectivity, sheet resistance and refractive index.

15. Thomson's experiment – To determine the e/m ratio of an electron.
16. Optical fibre characteristics – To determine the numerical aperture, attenuation and bandwidth.
17. Frank Hertz experiment – To determine the ionization potential.
18. Four probe method – To study the bulk resistance and the band gap energy of the given semiconductor.
19. LED characteristics – Determination of wavelength of emission, current-voltage characteristics and variation with temperature, variation of output power with applied voltage etc.
20. Photoelectric effect – Determination of Planck's constant (White light and filters or LEDs of different colours may be used).
21. Growth of a single crystal from the solution and determination of their structural, electrical and optical properties.
22. Study of colour centers – Thermo luminescence and glow curves.
23. Ionic conductivity in KCl and NaCl crystals.
24. Strain gauge – Y of a metal beam.
25. Solar cell – Spectral response and I-V characteristics.
26. Dielectric constant of a liquid by LCR Bridge.
27. Study of junction capacitance with voltage of P-N junction (Si, Ge and GaAs)
28. Michelson Interferometer – Determination of wavelength of He-Ne LASER.
29. Michelson interferometer – Determination of thickness of a mica sheet.
30. Thermo luminescence spectra of Alkali halides.
31. Variation of dielectric constant with temperature of a Ferroelectric material (Barium titanate).
32. Ferrite specimen – Variation of magnetic properties with composition.
33. Advanced Laser Experiments – Experiments with Hologram.
34. Zeeman Effect – To study the Zeeman splitting of the green mercury line using Fabry Perot etalon for the normal transverse and longitudinal configuration.
35. X ray Apparatus – To study diffraction of X rays.

TEACHING LEARNING STRATEGIES

- Demonstration, hands-on practice, repetition, and assessment.

MODE OF TRANSACTION

- Seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |

| | |
|---|---|
| ● Record | 5 |
| ● Internal tests | 35 |

**Sample Questions to test Outcomes.**

1. Determine ionization potential using the Frank Hertz experiment.
2. Determine velocity of an ultra-sound wave in a given liquid.
3. Obtain the carrier concentration of a semiconducting material using Hall apparatus
4. Demonstrate I-V characteristics of a solar cell.
5. Determine the young's modulus of metal using Strain gauge.

6.Obtain e/m ratio of an electron using Thomson's method.

**MSPHY03DSE0Y: DISCIPLINE SPECIFIC ELECTIVE III**

**MSPHY03DSE07: FUNCTIONAL MATERIALS AND DEVICES (3C)**

**MSPHY03DSE08: SEMICONDUCTOR MATERIALS AND DEVICES(3C)**

**MSPHY03DSE09: BIOPHYSICS (3C)**

**MSPHY03DSE07: FUNCTIONAL MATERIALS AND DEVICES**

**Module 1:** Ceramic Materials: Classification, Preparation and Properties, Composites, Smart Materials exhibiting: Ferroelectric, Dielectrics, Piezoelectric, Thermoelectric, Luminescence, Photocromics, Thermocromics and Electrocromic Materials, Phase Change Material, Shape Memory Alloys, Smart Structure and Robotics.

**Module 2:** Ferrites, Gaint magnetoresistance (GMR), Magnetic materials for recording and computers., Spin Polarization, Colossal Magnetoresistance (CMR), La and Bi-based Perovskite, Spin-Glass, Spintronics: Magnetic tunnel junction, Spin transfer torque, Applications, Multiferroics: Types and Mechanism, BiFeO 3 and BaTiO 3 Multiferroics.

**Module 3:** Basic Concepts on Polymers, Polymers (Insulating, electronic and functionalized), Polymer Configuration (Tacticity), Polymer Conformation (Trans, Staggered, Gauche, Eclipsed), Polymer processing: Hot moulding, Film blowing, Melt spinning etc Composites: Varieties, Role of Matrix Materials, Mixing Rules, Polymer composites and nanocomposites (PNCs), PNCs for Li-ion battery, Supercapacitor, fuel cell, LED's and solar cell, synthesis and engineering of PNCs.

**Module 4:** Devices: Photovoltaic, Solar Energy, Nanogenerators, LED, Electrochromic displays (n & p-type materials, electrolytes, device fabrication and property measurements), Resistive switching, Supercapacitor and Li-ion batteries (Types and Properties: Crystallinity, Free ions and ion pair's contribution, Ionic radii of migrating species, Ionic Conductivity, Transport parameters, Transference Number, Thermal Stability, Porosity and Electrolyte Uptake/Leakage, Thermal Shrinkage, Glass transition temperature, Electrochemical Stability, Mechanical Stability) Advantages and

Disadvantages, Ragone plot, Nyquist plot, Charging- discharging. Fuel Cell (Alkaline Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Direct Methanol Fuel Cell, Solid Oxide Fuel Cell,).

**Suggested Readings:**


1. Mel Schwartz, Smart Materials, CRC Press, Boca Raton, 2009.
2. Handbook of Inorganic Electrochromic Materials, by C.G. Granqvist; Elsevier Science, 1995.
3. Lithium Batteries: Advanced Technologies and Applications, by Bruno Scrosati, K. M. Abraham,
4. Walter Van Schalkwijk, and Jusef Hassoun; John Wiley & Sons, Inc, 2013.
5. Advanced functional materials: a perspective from theory and experiment. Edited by Biplab Sanyal, and Olle Eriksson.
6. S.B. Ogale, T.V. Venkatesan, M. Blamire, Functional Metal Oxides (Wiley-VCH Verlag GmbH, Germany) 2013.
7. S. Banerjee and A.K. Tyagi, Functional Materials: Preparation, Processing and Applications (Elsevier, Insights, Massachusetts, USA) 2011.
8. D.D.L. Chung, Composite Materials: Functional Materials for Modern Technologies (Springer, New York, USA) 2003.
9. Deborah D. L. Chung, Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications (World Scientific Publishing Company, Singapore) 2010.
10. B.D. Cuility and C.D. graham, Introduction to Magnetic Materials (Willey, New Jersey) 2009.
11. K.C. Kao, Dielectric Phenomena in Solids (Elsevier, Academic Press, London, U. K.) 2004.
12. S. O. Kasap, Principles of Electronic Materials and Devices (McGraw Hill Publications)
13. B E Conway Brian E Conway Conway, Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications (Springer) 1999


**MSPHY03DSE08: SEMICONDUCTING MATERIALS AND DEVICES**

**Objectives:** In the present era of electronic and optoelectronic devices, semiconductor materials play a significant role. So, the primary objective of this elective pater is to provide the students an understanding of basic and advanced properties of semiconductor materials as well as their functioning in some of the applications. Students will learn the physical behaviour of bipolar junction transistors and field effect transistors by forming semiconductor junctions. Further, the principle and working of optoelectronic devices such as solar cells, photodetectors, light emitting diodes etc. will also be elaborated.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

## COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the basic and advanced properties of semiconductor materials. |
| **C02** | Describe the importance of semiconductor materials in various device applications. |
| **CO3** | Illustrate working of bipolar junction transistors and field effect transistors on a semiconductor perspective. |
| **C04** | Describe the principle and working of optoelectronic devices such as solar cells, photodetectors, light emitting diodes etc. |

## COURSE CONTENTS

**Module I**

1.1. Carrier Drift, 1.2. Drift Current Density, 1.3. Mobility Effects, 1.4. Conductivity, 1.5. Velocity Saturation, 1.6.Carrier Diffusion, 1.7.Diffusion Current Density, 1.8.Total Current Density, 1.9.Graded Impurity Distribution, 1.10.Induced Electric Field, 1.11.The Einstein Relation, 1.12.Reciprocal Lattice, 1.13.Bragg Reflection of Electron Waves, 1.14.Brillouin Zones, 1.15.Important Features of Energy Bands of Si, Ge and GaAs

**Suggested readings specific to the module**

1.1. Donald A. Neamen (4.1), 1.2. Donald A. Neamen (4.1.1), 1.3. Donald A. Neamen (4.1.2), 1.4. Donald A. Neamen (4.1.3), 1.5. Donald A. Neamen (4.1.4), 1.6. Donald A. Neamen (4.2), 1.7. Donald A. Neamen (4.2.1), 1.8. Donald A. Neamen (4.2.2), 1.9. Donald A. Neamen (4.3), 1.10.Donald A. Neamen (4.3.1), 1.11.Donald A. Neamen (4.3.2), 1.12.Michael Shur (1.5), T3 (1.2.2), 1.13.Michael Shur (1.5), 1.14.Michael Shur (1.5), T3 (1.2.2), 1.15.Michael Shur (1.5), Donald A. Neamen (2.7.1), T3 (1.3)

**Module II**

2.1. Intrinsic, Extrinsic and Compensated Semiconductors, 2.2. Electrons and Holes: Semiconductor Statistics, 2.3. Electron and Hole Mobilities and Drift Velocities, 2.4. Hall Effect and Magneto resistance, 2.5. Quasi Fermi Levels: Generation and Recombination of Carriers, 2.6. p-n Junction under Zero Bias Condition, 2.7. Depletion Capacitance, 2.8. Diffusion Capacitance, 2.9. Tunneling and Tunnel Diodes, 2.10.Junction Breakdown, 2.11.Schottky Barriers, 2.12.Ohmic Contacts.

**Suggested readings specific to the module**

2.1. Michael Shur (Section 1.7), 2.2. Michael Shur (Section 1.6), 2.3. Michael Shur (Section 1.9), 2.4. Michael Shur (Section 1.10), 2.5. Michael Shur (Section 1.12), 2.6. Michael Shur (Section 2.2), 2.7. Michael Shur (Section 2.5), 2.8. Michael Shur (Section 2.6), 2.9. Michael Shur (Section 2.7), 2.10.Michael Shur (Section 2.8), 2.11.Michael Shur (Section 2.9), 2.12.Michael Shur (Section 2.11)

**Module III**

3.1. Bipolar Junction Transistor: Principle of Operation, 3.2. Doping Profile, 3.3. Electron Diffusion Current in the Base, 3.4. BJT as a Switch, 3.5. Bipolar Transistors in Integrated Circuits, 3.6. FET: Basic Principles, 3.7. Surface Charge in Metal Oxide Semiconductor Capacitors, 3.8. MOSFET: Principle of Operation, 3.9. Charge Coupled Devices, 3.10.Advanced MOS Devices

**Suggested readings specific to the module**

3.1. Michael Shur (Section 3.1), 3.2. Michael Shur (Section 3.1), 3.3. Michael Shur (Section 3.1), 3.4. Michael Shur (Section 3.12), 3.5. Michael Shur (Section 3.13), 3.6. Michael Shur (Section 4.1), 3.7. Michael Shur (Section 4.2), 3.8. Michael Shur (Section 4.4.1), 3.9. Sze S. M. (Section 13.6)

**Module IV**

4.1. Crystalline Solar Cells, 4.2. Conversion Efficiency, 4.3. p-n Junction Solar Cells, 4.4. Spectral Response – Equivalent Circuit, 4.5. Amorphous Silicon Solar Cells, 4.6. Photo Detectors, 4.7. PIN Diode Detectors, 4.8. Electroluminescence of Electromagnetic Waves in Two Level Systems, 4.9. LEDs, 4.10.Semiconductor Lasers: Optical Gain, 4.11.Integrated Optoelectronics

**Suggested readings specific to the module**

4.1. Michael Shur (Section 5.2), 4.2. Donald A. Neamen (Section 10.2.2), 4.3. Donald A. Neamen (Section 10.2.1), 4.4. Sze S. M. (Section 13.9.3), 4.5. Donald A. Neamen (Section 10.2.4), 4.6. Donald A. Neamen (Section 10.3), 4.7. Donald A. Neamen (Section 10.3.3), 4.8. Michael Shur (Section 5.5), 4.9. Michael Shur (Section 5.5), 4.10.Michael Shur (Section 5.6), 4.11.Michael Shur (Section 5.7)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. Michael Shur, Physics of Semiconductor Devices, Prentice Hall of India, 2004.
2. Donald A. Neamen, Semiconductor Physics and Devices by, Fourth Edition, 2019.
3. Sze S. M., Physics of Semiconductor Devices, John Wiley & Sons, 2015.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. S. S. Islam, Semiconductor Physics and Devices, Oxford University Press, 2010.
2. Karl Hess, Advanced Theory of Semiconductor Devices, Prentice Hall of India.
3. Jasprit Singh, Semiconductor Devices: An Introduction, McGraw Hill, 2001.

**TEACHING LEARNING STRATEGIES**

● Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

● Lectures, seminars, discussions, and demonstrations.

**ASSESSMENT RUBRICS**

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**MSPHY03DSE09: BIOPHYSICS**

**COURSE OBJECTIVES:** The students will have a solid understanding of the fundamentals of biophysics and its related fields, such as protein structure determination, after completing this course.

**COURSE CONTENTS**

**Module 1:** Fundamental building blocks of biological systems, Molecules essential for life, Water, proteins, lipids, carbohydrates, cholesterol, Nucleic acid, living state interactions, forces and molecular bonds, electric and thermal interaction, -polarisations and induced dipoles, Casimir interactions, heat transfer in biomaterials, heat transfer mechanisms, heat equation, heat transfer through a living cell, Joule heating tissue

**Module 2:** Living state thermodynamics, thermodynamic equilibrium, First and second law of thermodynamics, measures of entropy, free expansion of gas, physics of many particle systems, Boltzmann factor in biology, DNA stretching, Brownian motion, Ficks laws of diffusion, Ficks law for growing bacterial cultures, Sedimentation of cell cultures.

**Module 3:** Nerve impulses, Neurotransmitters and synapses, Passive and active transports in dendrites, Mechanical properties of biomaterials, Youngs, shear modulus and Poisson ratio, electrical stresses in biological membranes, Mechanical effects of microgravity during space flight,fundamentals of biomagnetic field sources- fundamentals Passive electrical properties of living cells.

**Module 4:** Light absorption in biomolecules, Bioimpedance, Time harmonic current flow, Dielectric spectroscopy, Debye relaxation model, Cole equation, Fundamentals of protein folding, basic techniques for protein folding, protein crystallization, Vapor diffusion, sitting drop method, Hanging drop method, Basics of structure determination of proteins with X-ray crystallography, sample handling techniques.

**Text Books:**

1. Introductory biophysics perspectives on the living state J.Claycomb, J.QuocP.Tran, Jones & Bartlett Publishers.
2. Biophysics; N. Arumugam, V. Kumaresan, Saras publication.
3. Biological Physics; Philip Nelson; W. H. Freeman &Company; 2013.
4. Protein Folding; Charis Ghelis; Academic Press;1982.
5. Preparation and Analysis of Protein Crystals; McPherson, A. 1982, John Wiley & Sons.
6. Terese M. Bergfors, Protein Crystallization Techniques, Strategies and Tips, International University Line, 1999.

**MSPHY03MDC0X: MULTI-DISCIPLINARY ELECTIVE**

**MSPHY03MDC01: ENERGY PHYSICS (4C)**

**MSPHY03MDC02: INTRODUCTION TO NANOMATERIALS (4C)**

**MSPHY03MDC01: ENERGY PHYSICS**

**Objectives:** This course is mainly designed for students from any backgrounds such as science, arts, commerce etc. Main aim of the course is to provide basic knowledge on Energy resources and the need for conservation of energy. Besides, to make the students acquire an awareness of Solar energy, solar energy conversion and importance of solar energy in the present scenario. Finally, it is intended to help them grasp a broad outline of different energy sources like ocean energy, wind energy etc.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

## COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain energy policy perspectives. |
| **C02** | Describe various technologies for conversion of solar energy resources and illustrate Photovoltaic conversion mechanism. |
| **C03** | Use of wind energy conversion. |
| **C04** | Describe various modes for ocean energy conversion |

## COURSE CONTENTS

### MODULE I

Overview of world energy scenario; Energy Demand- present and future energy requirements; Review of conventional energy resources- Coal, gas and oil reserves, Tar sands and Oil Shale, Nuclear energy; Global warming; Green House Gas emissions, impacts, mitigation; sustainability; United Nations Framework Convention on Climate Change (UNFCCC); Sustainable development; Kyoto Protocol; Conference of Parties (COP); Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF).

### MODULE II

Solar Energy -Solar radiation, its measurements and prediction; Solar thermal collectors- flat plate collectors, concentrating collectors; solar heating of buildings; solar still; solar water heaters; solar dryers; conversion of heat energy in to mechanical energy, solar thermal power generation systems; Photovoltaic Conversion -Intrinsic, extrinsic and compound semiconductor; Absorption of light; Recombination process; p-n junction: homo and hetero junctions; Dark and illumination characteristics; Principle of photovoltaic conversion of solar energy, Figure of merits of solar cell; Efficiency limits;

### MODULE III

Wind Energy -Wind energy conversion principles; General introduction; Power, torque and speed characteristics. Atmospheric circulations; factors influencing wind, wind shear, turbulence, wind speed monitoring; Betz limit; Types and classification of WECS, characteristics and applications.

### MODULE IV

Ocean Energy - Ocean energy resources, ocean energy routes; Principles of ocean thermal energy conversion systems; ocean thermal power plants; Principles of ocean wave energy conversion and tidal energy conversion.

**Reference Books:**

1. Non- conventional energy resources, B H Khan, Tata McGraw-Hill Publication 2006, ISBN 0-07-060654-
2. Renewable Energy Resources Paperback John Twidell and Tony Weir, Routledge, Taylor& Francis, 2015 ISBN 9780415584388
3. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Pvt. Ltd., Third Edition 2015, ISBN 978-81-203-5111-0
4. Non-Conventional Energy Resources: G. D. Rai, Khanna Publishers,2008.
5. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
6. Renewable Energy, Bent Sorensen (2nd Ed), Academic press, New York, 2000

**TEACHING LEARNING STRATEGIES**

- Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

**ASSESSMENT RUBRICS**

| **Description** | **Marks** |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

## MSPHY03MDC02: INTRODUCTION TO NANOMATERIALS

## COURSE CONTENTS

### MODULE I

Fundamentals of Nanomaterials, History of Nanotechnology, Feynman's vision on Nano Science & technology, bulk vs nanomaterials. Central importance of nanoscale morphology - small things making big differences, nanotechnology as natures technology, clusters and magic numbers. nanoscale architecture. Recent developments, challenges and future prospects of nanomaterials.

### MODULE II

Size and shape dependent properties of nanomaterials Size and shape dependent properties, Melting points and lattice constants. Surface Tension, density of states, Wettability - Specific Surface Area and Pore - Composite Structure - Mechanical properties. Optical properties: Basic principles of nanomaterials- increase in surface area to volume ratio and quantum confinement effect. Surface Plasmon resonance in metal nanoparticles and quantum size effect in Semiconductors, Electrical conductivity: Surface scattering, change of electronic structure, quantum transport. effect of microstructure

### MODULE III

Classification of nanomaterials Classification based on the dimensionality. Zero-dimensional nanostructures: metal, semiconductor and oxide nanoparticles. One-dimensional nanostructures: nanowires and nanorods. two-dimensional nanostructures: thin films. Three-dimensional nanomaterials. Special Nanomaterials: Carbon fullerenes and carbon nanotubes. micro and mesoporous materials. core-shell structures. organic-inorganic hybrids.

### MODULE IV

Surface science for nanomaterials, surface energy, Surface Energy minimization: Sintering Ostwald ripening and agglomeration. Energy minimization by Isotropic and anisotropic surfaces. Wulff plot, Surface energy, surface curvature and chemical potential. Surface energy stabilization mechanisms. Electrostatic stabilization - Point zero charge (p.z.c). Nernst Equation. Electric double layer. Electric potential at the proximity of a solid surface - Debyo-tluckcl Screening strength. Interaction between nanoparticles - Van der Waals attraction potential. DLVO Theory. static stabilization and electro static stabilization. Nucleation and growth of nuclei. critical radius, homogenous and heterogeneous nucleation.

### REFERENCES

l. A.W. Adamson and A.P.Cast, Physical Chemistry of surfaces, Wiley lnterscience. NY 2004.

2. G. Cao and Y. Wang, Nanostructures and Nanomaterials, 2nd Ed., lmperial College Press, 2004. 3. R. Kelsall. L Hamley and M. Ceoghegan, Nanoscale Science and Technology, Wiley. 2005.

4. K. J. Klabunde. R. M. Richards, Nanoscale Materials in Chemistry,2nd Ed., Wiley,2009.

5. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education. 2012.

6. G. Schmidt. Nanoparticles: From Theory to applications. Wiley-VCH.2004

7. Malkiat S. Johal, Lewis E. Johnson, Textbook Series in Physical Sciences, CRC Press, Year: 201 8. G. Cao, Nanostructures & Nanomaterials; Synthesis, Properties &Application, Imperial College Press, 2004.

**Course Description**

**SEMESTER IV**

**DISCIPLINE SPECIFIC CORE COURSES**

**MSPHY04DSC14: STATISTICAL MECHANICS**

Objectives: Statistical mechanism is a formalism which aims at explaining the physical properties of matter in bulk on the basis of the dynamical behaviour of its microscopic constituents. The formalism is almost as unlimited as the very range of natural phenomena. This paper is aiming to make us understand some of the previously studied thermodynamic phenomena in terms of the microscopic parameters by using the statistical mechanics tool. The paper begins with bridging macroscopic and microscopic worlds and after that introduces ensemble formalism. After that the basic ideas of quantum statistical mechanics and fundamentals of Ising theory will be studied.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 4 | - | 4 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

**COURSE OUTCOMES**

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

| | |
|---|---|
| C01 | Explain the macroscopic phenomena (any natural phenomena) in terms of the microscopic parameters or to bridge the microscopic and macroscopic worlds. |
| C02 | Elucidate the connection between the thermodynamic and statistical parameters. |
| C03 | Describe the different ensemble formalism and differentiate micro canonical, canonical and grand canonical ensembles |
| C04 | Apply statistical mechanics as a tool to solve various physical situations related to classical and quantum mechanical systems with specific examples like Bose Einstein Condensation and black body radiation. |
| C05 | Explain how a complete theoretical model named Ising model explains the physical phenomenon like phase transition. |

COURSE CONTENTS

**Module 1**

1.1 The Macroscopic and Microscopic States, 1.2 Contact Between Thermodynamics and Statistics, 1.3 Classical Ideal Gas, 1.4 Gibbs Paradox, 1.5 Phase Space, 1.6 Liouville's Theorem

**Suggested readings specific to the module.**

1.1 R K Pathria (Section 1.1), 1.2 R K Pathria (Section 1.2), 1.3 R K Pathria (Section 1.4), 1.4 R K Pathria (Section 1.5), 1.5 R K Pathria (Section 2.1), 1.6 R K Pathria (Section 2.2)

**Module 2**

2.1 Ensembles: Micro Canonical Ensemble, 2.2 Quantization of Phase Space, 2.3 Canonical Ensemble, 2.4 Equilibrium Between System and Reservoir (Boltzmann distribution), 2.5 Ensemble approach, 2.6 Physical Significance of Statistical Quantities, 2.7 Classical Systems, 2.8 Energy Fluctuations, 2.9 Equipartition Theorem and Virial Theorem, 2.10 A System of harmonic oscillators, 2.11 The statistics of paramagnetism, 2.12 Grand Canonical Ensemble, 2.13 Equilibrium Between System and Reservoir (Gibbs distribution), 2.14 Significance of Statistical Quantities, 2.15 Energy and Density Fluctuations.

**Suggested readings specific to the module.**

2.1 R K Pathria (Section 2.3,2.4), 2.2 R K Pathria (Section 2.5), 2.3 R K Pathria (Section 3rd chapter), 2.4 R K Pathria (Section 3.1), 2.5 R K Pathria (Section 3.2), 2.6 R K Pathria (Section 3.3), 2.7 R K Pathria (Section 3.5), 2.8 R K Pathria (Section 3.6), 2.9 R K Pathria (Section 3.7), 2.10 R K Pathria (Section3.8), 2.11 R K Pathria (Section 3.9), 2.12 R K Pathria (Section 4th chapter), 2.13 R K Pathria (Section 4.1,4.2), 2.14 R K Pathria (Section 4.3), 2.15 R K Pathria (Section 4.5)

**Module 3**

3.1 Density Operator, 3.2 Statistics of Various Ensembles, 3.3 Ideal Gas in a Quantum Mechanical Microcanonical, 3.4 Canonical Ensemble, 3.5 Behavior of Ideal Bose Gas, 3.6 Bose-Einstein Condensation, 3.7 Planck's Theory of Blackbody Radiation, 3.8 Debye Theory of Specific Heat

**Suggested readings specific to the module.**

3.1 R K Pathria (Section 5.1), 3.2 R K Pathria (Section 5.2), 3.3 R K Pathria (Section 6.1), 3.4 R K Pathria (Section 6.2), 3.5 R K Pathria (Section 7.1), 3.6 R K Pathria (Section 7.2), 3.7 R K Pathria (Section 7.3), 3.8 R K Pathria (Section 7.4)

**Module 4**

4.1 Behavior of an Ideal Fermi Gas, 4.2 Electron Gas in Metals, 4.3 Landau diamagnetism, 4.4 de Hass van Alphen Effect, 4.5 Statistical Equilibrium of White Dwarfs, 4.6 Dynamical Model of Phase Transitions, 4.7 The Lattice Gas and Binary Alloy, 4.8 Ising Model in the Zeroth and First Approximation, 4.9 Critical Exponents, 4.10 Ising Model in One Dimension

**Suggested readings specific to the module**

4.1 R K Pathria (Section 8.1,8.2), 4.2 R K Pathria (Section 8.3), 4.3 R K Pathria (Section 8.2b), 4.4 Landau and Lifshitz (Section 60,5th chapter), 4.5 R K Pathria (Section 8.5), 4.6 R K Pathria (Section 12.3), 4.7 R K Pathria (Section 12.4), 4.8 R K Pathria (Section 12.5,12.6), 4.9 R K Pathria (Section 12.7), 4.10 R K Pathria (Section 13.2)

**Core Compulsory Readings (Books, Journals, E-sources Websites/ weblinks)**

1. R. K. Pathria, Statistical Mechanics, Butterworth Heinemann (3rd Edition).

**Core Suggested Readings (Books, Journals, E-sources Websites/ weblinks)**

1. Kerson Huang, Statistical Mechanics, John Wiley & Sons.
2. Landau &Lifeshitz, Statistical Physics, Pergman.
3. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw Hill.

TEACHING LEARNING STRATEGIES

Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

MODE OF TRANSACTION

- Lectures, seminars, discussions, and demonstrations.

ASSESSMENT RUBRICS

| Description | Marks |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| ● Assignments | 8 |
| ● Internal tests | 16 |
| ● Seminar | 6 |
| ● Viva | 10 |

**Sample Questions to test Outcomes.**

1. Describe macrostate and microstate.
2. State and explain Lioville's theorem.
3. Explain Gibb's paradox.
4. Obtain expression for probability of seeing a system in a canonical ensemble with energy E.
5. Explain the density fluctuation in grand canonical ensemble
6. Describe Ising model.

**MSPHY04DSC15: INDUSTRIAL VISIT**

**Objectives:** Students will have to visit a Research institute of National repute to have an idea about the current research activities. The report of the same may be submitted to the Head of the Department for valuation.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| - | - | 2 | - | - | - | 100 | - | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

ASSESSMENT RUBRICS

| **Description** | **Marks** |
|---|---|
| **Continuous Evaluation** | **100** |

**MSPHY04DSC16: PROJECT**

**Objectives:** Each student shall carry out a project work in any branch of Physics /Material science for a period of not more than three months. The project can be carried out in a research Institute/industry of national repute with guidance from experts there.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| - | 4 | 4 | - | 15 | 15 | - | 100 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

ASSESSMENT RUBRICS

| **Description** | **Marks** |
|---|---|
| **End Semester Evaluation** | **100** |

## MSPHY04DSE0X: DISCIPLINE SPECIFIC ELECTIVE IV

## MSPHY04E10: PARTICLE PHYSICS AND ASTROPHYSICS

**Objectives:** The course on particle physics gives a modern explanation of theory and matter that we encounter every day. The theory developed with the classification of forces exists in nature. The modern explanation of the strong nuclear force was proposed by Yukawa. The concept of modern quantum numbers like baryon, strangeness, isospin, the third component of isospin etc are well explained apart from the classical quantum numbers like energy, angular momentum, linear momentum and charge. Quark model developed by Gell-Mann which considers quark as the fundamental building block for the atoms. Even Though the lack of experimental evidence for the existence of quark is there, still most of the phenomenon associated with the atom is very well explained using the quark model. Astrophysics course on the other hand gives a detailed description of the evolution of the stars, big bang theory and the Harward system of the classification of the stars is very well explained. The concepts like formation of protostars, derivation of the Chandrasekhar limit and the theory about black holes are also the objectives of this course.

| **Credit** | | | **Teaching Hours** | | | **Assessment** | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

## COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the reason why the strong nuclear force is extremely strong and the range of nuclear force is of the order of nuclear radius and explain how the Heisenberg uncertainty relations connecting energy and time is used to deduce the range of nuclear force. |
| **C02** | Describe the concept of resonance and the detection of the resonant particles using resonance production experiment and the resonance formation in experiment. |
| **C03** | Illustrate the conservation laws and intrinsic quantum numbers like baryon, strangeness, isospin, third components of isospin etc. |
| **C04** | Describe the basic building block of matter and their discovery. And explain the theory of the standard model of particle physics. |

| | |
|---|---|
| **C05** | Explain the absolute and apparent magnitudes, the Harvard model of the classification of the stars, and the Hertzsprung – Russell Diagram for the representation of the stars. |
| **CO6** | Describe the concepts like interstellar gas, the cooling of the white dwarf, neutron stars and the formation and the detection of the black holes |

**COURSE CONTENTS**

**Module 1**

1.1 Strong and Weak Nuclear Forces, 1.2 Yukawa's Proposal, 1.3 Pair Production, 1.4 Properties and Modes of Decay of Pions and Muons, 1.5 The Muon, 1.6 The Real Pion, 1.7 Isotopic Spin, 1.8 Strange Particles, 1.9 Gell Mann-Nishijima Formula, 1.10 Extremely Short-Lived Particles, 1.11Resonances and Their Quantum Numbers with Special Reference to Pions, 1.12 Nucleon Scattering, 1.13 Conservation Laws, 1.14 Intrinsic Quantum Numbers Associated with Elementary Particles, 1.15 Theory of Weak Interaction, 1.16 Parity Non-conservation, 1.17 The TCP Theorem, 1.18 Unification of Weak Electromagnetic Interaction, 1.19 The Glashow-Weinberg-Salam Model

**Suggested readings specific to the module.**

1.1 G. D. Coughlan and J. E. Dodd (Section 5.4 and 5.5 ), 1.2 G. D. Coughlan and J. E. Dodd (Section 7.2), 1.3 Yuval Ne'eman and Yoram Kirsh (Section 2.1), 1.4 G. D. Coughlan and J. E. Dodd (Section 7.4), 1.5 G. D. Coughlan and J. E. Dodd (Section 7.3), 1.6 G. D. Coughlan and J. E. Dodd (Section 7.4), 1.7 G. D. Coughlan and J. E. Dodd (Section 7.6), 1.8 G. D. Coughlan and J. E. Dodd ( Chapter 8), 1.9 G. D. Coughlan and J. E. Dodd (Section 8.2), 1.10 Yuval Ne'eman and Yoram Kirsh (Section 8.1), 1.11 Yuval Ne'eman and Yoram Kirsh (Section 8.2 and 8.3), 1.12 Yuval Ne'eman and Yoram Kirsh (Section 8.2), 1.13Yuval Ne'eman and Yoram Kirsh ( Chapter 7), 1.14 Yuval Ne'eman and Yoram Kirsh (Section 7.6, 7.7 and 7.8), 1.15 Yuval Ne'eman and Yoram Kirsh (Section 6.1), 1.16 Yuval Ne'eman and Yoram Kirsh (Section 7.10), 1.17 Yuval Ne'eman and Yoram Kirsh (Section 7.9), 1.18 Yuval Ne'eman and Yoram Kirsh (Section 6.1), 1.19 Yuval Ne'eman and Yoram Kirsh (Section 6.1), G. D. Coughlan and J. E. Dodd (Chapter 22)

**Module 2**

2.1 Quark Model, 2.2 The Sakata Model, 2.3 The Eight-Fold way, 2.4 Gell-Mann-Okubo and Coleman-Glashow Equations, 2.5 Quarks and Quark Models, 2.6 Different Types, 2.7 The Confined Quarks, 2.8 Experimental Evidence for the Existence of Quarks, 2.9 Coloured Quarks, 2.10 Charm, Truth and Beauty

2.1 Yuval Ne'eman and Yoram Kirsh (Section 9.4), 2.2 Yuval Ne'eman and Yoram Kirsh (Section 9.1), 2.3 Yuval Ne'eman and Yoram Kirsh (Section 9.2), 2.4 Yuval Ne'eman and Yoram Kirsh (Section 9.2), 2.5 Yuval Ne'eman and Yoram Kirsh (Section 9.4), 2.6 Yuval Ne'eman and Yoram Kirsh (Section 9.4), 2.7 Yuval Ne'eman and Yoram Kirsh (Section 9.5), 2.8 Yuval Ne'eman and Yoram Kirsh (Section 9.6), 2.9 Yuval Ne'eman and Yoram Kirsh (Section 9.7), 2.10 Yuval Ne'eman and Yoram Kirsh (Section 10.1 and 10.6)

**Module 3**

3.1 Absolute Magnitude and Distance Modulus, 3.2 Colour Index of Stars, 3.3 Luminosities of Stars, 3.4 Stellar Parallax and Units of Stellar Distance, 3.5 Celestial Sphere and Celestial Coordinate Systems, 3.6 Harvard System of Classification of Stars, 3.7 Spectroscopic Parallax, 3.8 The Hertzsprung – Russell Diagram.

3.1 Baidyanath Basu (Section 3.2), 3.2 Baidyanath Basu (Section 3.6), 3.3 Baidyanath Basu (Section 3.7), 3.4 Baidyanath Basu (Section 3.8), 3.5 Baidyanath Basu (Section 3.9), 3.6 Baidyanath Basu (Section 4.4), 3.7 Baidyanath Basu (Section 4.7), 3.8 Baidyanath Basu (Section 4.8)

**Module 4**

4.1 Interstellar Dust and Gas, 4.2 The Formation of Protostars, 4.3 Pre-main Sequence: Evolution, 4.4 Evolution of the Main Sequence, 4.5 Late Stages of Degenerate Matter, 4.6 The Chandrasekhar Limit, 4.7 The Cooling of White Dwarfs, 4.8 Neutron Stars, 4.9 Pulsars, 4.10 Quasars, 4.11 Black Holes, 4.12 Comets, 4.13 Asteroids and Meteorites, 4.14 The Formation of the Solar System.

**Suggested readings specific to the module**

1.1 Bardley W. Carrol & Dale A. Ostile (Section 12.1), 1.2 Bardley W. Carrol & Dale A. Ostile (Section 12.2), 1.3 Bardley W. Carrol & Dale A. Ostile (Section 12.3), 1.4 Bardley W. Carrol & Dale A. Ostile (Section 13.1), 1.5 Bardley W. Carrol & Dale A. Ostile (Section 13.1), 1.6 Bardley W. Carrol & Dale A. Ostile (Section 13.1), 1.7 Bardley W. Carrol & Dale A. Ostile (Section 16.5), 1.8 Bardley W. Carrol & Dale A. Ostile (Section 16.6), 1.9 Bardley W. Carrol & Dale A. Ostile (Section 16.7), 1.10 Bardley W. Carrol & Dale A. Ostile (Section 28.1), 1.11 Bardley W. Carrol & Dale A. Ostile (Section 17.3), 1.12 Bardley W. Carrol & Dale A. Ostile (Section 22.2), 1.13 Bardley W. Carrol & Dale A. Ostile (Section 22.3 and 22.4), 1.14 Bardley W. Carrol & Dale A. Ostile (Section 23.2)

**Core Compulsory Readings (**Books, Journals, E-sources Websites/ weblinks)

1. G. D. Coughlan and J. E. Dodd, The Ideas of Particle Physics, Cambridge University Press, 1991. (Third edition)
2. Yuval Ne'eman and Yoram Kirsh, Particle Hunters, Cambridge University Press, 1996. (Second edition)
3. Baidyanath Basu, An Introduction to Modern Astrophysics, Prentice Hall of India. (Second edition)
4. Bardley W. Carrol & Dale A. Ostile, An Introduction to Modern Astrophysics, Addison Wesley. (Second edition)

5. David Griffith, Introduction to Elementary Particle Physics, John Wiley & Sons.
6. M. P. Khanna, Introduction to Particle Physics, Prentice Hall of India.

**Core Suggested Readings (**Books, Journals, E-sources Websites/ weblinks)

1. Narlikar J. V. and Ajith K. Kembhavi, Quasars and Active Galactic Nuclei.
2. Narlikar J. V., Introduction to Cosmology.
3. Sinha B. C., Srivastava D. K., Viyogi Y. P., Physics and Astrophysics of Quark-Gluon, Narosa Publishing House, New Delhi.
4. Hughes, Elementary Particles – 2 nd Edition, Cambridge University Press.

**TEACHING LEARNING STRATEGIES**

Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

**MODE OF TRANSACTION**

- Lectures, seminars, discussions, and demonstrations.

**ASSESSMENT RUBRICS**

| **Description** | **Marks** |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

**MSPHY04DSE11: GENERAL THEORY OF RELATIVITY**

**COURSE CONTENTS**

**Module 1**

1.1 Special Relativity, 1.2 Oblique Axes, 1.3 Curvilinear Coordinates, 1.4 Non-tensors and the Quotient theorem, 1.5 Curved Space, 1.6 Parallel Displacement, 1.7 Christoffel Symbols, 1.8 Geodesics, 1.9 The stationary Property of

Geodesics, 1.10 Covariant Differentiation, 1.11 The Curvature tensor, 1.12 The Condition for Flat Space, 1.13 The Bianci Relations. 1.14 Strong and Weak Nuclear Forces

**Module 2**

2.1 The Ricci Tensor, 2.2 Einstein's Law of Gravitation, 2.3 The Newtonian Approximation, 2.4 The Gravitational Red Shift, 2.5 The Schwarzschild Solution, 2.6 Black Holes, 2.7 Tensor Densities, 2.8 Gauss and Stokes Theorem, 2.9 Harmonic Coordinates, 2.10 The Electromagnetic Field, 2.11 Modification of Einstein's Equations by presence of Matter, 2.12 The Material Energy tensor, 2.13 The Gravitational Action Principle.

**Core Compulsory Readings**

General Theory of Relativity, P. A. M. Dirac, Princeton University Press.

**Core Suggested Readings**

1. First Course in General Relativity, 2 e, Bernard Schutz, Cambridge.
2. Space-time and Geometry, Sean M. Carroll, Pearson.
3. A Course in Modern Mathematical Physics, Peter Szekeres, Cambridge.

**MSPHY04DSE12: QUANTUM FIELD THEORY**

**COURSE CONTENTS**

**Module 1**

Canonical Quantization:1.1 General Formulation, 1.2 Conjugate Momentum and Quantization, 1.3 Neutral Scalar Field Commutation Relations, 1.4 Normal Ordering, 1.5 Bose Symmetry, 1.6 Fock Space, 1.7 Charged Scalar Field, 1.8 U(1) Invariance, 1.9 Charge Conservation, 1.10 Particles and Antiparticles, 1.11 Time Ordered Product, 1.12 Feynman Propagator for Scalar Fields, 1.13 Bose-Einstein Distribution, 1.14 Propagators at Finite Temperature.

**Module 2**

Dirac Field:2.1 The Dirac Equation, 2.2 Relativistic Covariance, 2.3 Anti-Commutators. 2.4 Quantization of the Dirac Field, 2.5 Electrons and Positrons, 2.6 Connection between Spin and Statistics, 2.7 Discrete Symmetries, 2.8 Parity, 2.9 Charge Conjugation, 2.10 Time Reversal, 2.11 CPT Theorem.

**Module 3**

Gauge Field: 3.1 Gauge Invariance and Gauge Fixing, 3.2 Quantization of the Electromagnetic Field, 3.3 Propagator, 3.4 Vacuum Fluctuations.

**Module 4**

Interacting Theory and Elementary Processes:4.1 Wick's Theorem, 4.2 Feynman Rules and Feynman Diagrams for Spinor Electrodynamics, 4.3 Lowest Order Cross-Section for Electron-Electron, 4.4 Electron-Positron and Electron-Photon Scattering.

**Reference**

1. Quantum Field Theory, C. Itzykson and J. B. Zuber, McGraw-Hill Book Co, 1985.
2. Quantum Field Theory, L. H. Ryder, Cambridge University Press, 2008.
3. Field Theory, A Modern Primer, P. Ramond, Benjamin, 1980.
4. The Quantum Theory of Fields, Vol I, S. Weinberg, Cambridge University Press, 1996.
5. Introduction to The Theory of Quantum Fields, N. N. Bogoliubov and D. V. Shirkov, Interscience, 1960.
6. An Introduction to Quantum Field Theory, M. E. Peskin and D. V. Schroeder, Westview Press, 1995.

**DISCIPLINE SPECIFIC ELECTIVE COURSE**

**MSPHY04DSE0Y: DISCIPLINE SPECIFIC ELECTIVE V**

**MSPHY04DSE13: THIN FILM TECHNOLOGY**

**Objectives:** The main objectives of the course are to study theory of thin film formation and various factors to affect the structure of thin films. Next is an expertizing different thin film fabrication and characterization techniques. This course also covers important properties and application of thin films.

| **Credit** | | | **Teaching Hours** | | | **Assessment** | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to -**

| | |
|---|---|
| **C01** | Explain the basics of thin films, the theory of thin film formation, and the various factors affecting the structure of thin films. |
| **C02** | Illustrate the different techniques for thin film fabrication like vacuum evaporation, pulsed laser ablation, sputtering, chemical vapor deposition etc. |

| | |
|---|---|
| **C03** | Describe how to measure the thickness of thin films and explain the different characterization techniques like XRD, Uv-Vis spectroscopy, SEM, TEM etc and study its theory, construction and working in detail. |
| **C04** | Explain the attenuation mechanisms |
| **C05** | Describe different applications of thin films in technology and daily life. |

**COURSE CONTENTS**

**Module I**

1.1 Thin Film Physics: Mechanism of Thin Film Formation, 1.2 Formation Stages of Thin Films, 1.3 Condensation and Nucleation, 1.4 Thermodynamic Theory of Nucleation, 1.5 Growth and Coalescence of Islands, 1.6 Influence of Various Factors on the Final Structure of Thin Films, 1.7. Crystallographic Structure of Thin Films.

**Suggested readings specific to the Module I**

1.1 T2 (Chapter 4, Section 1), 1.2 T2 (Chapter 4, Section 1), 1.3 T2 (Chapter 4, Section 1.1)

1.4 T2 (Chapter 4, Section 1.3), 1.5 T2 (Chapter 4, Section 2.2), 1.6 T2 (Chapter 4, Section 2.3), 1.7 T2 (Chapter 4, Section 4)

**Module II**

2.1 Methods of Preparation/Synthesis of Thin Films: Vacuum Evaporation, 2.2 Resistive Heating, 2.3 Electron Beam Evaporation and Laser Beam Evaporation, 2.4 Sputtering: Glow Discharge, Radio Frequency and Magnetron Sputtering, 2.5 Chemical Methods: LCVD, PCVD and PECVD, 2.6 Spray Method: Spray Hydrolysis and Spray Pyrolysis, 2.7 Langmuir Blochet Technique, 2.8 Sol-gel Deposition., 2.9 Thickness Measurements, 2.10 Resistance, Capacitance, 2.11 Microbalance, Quartz Crystal Thickness Monitor, 2.12 Optical Absorption, Multiple Beam Interference, Interference Colour and Ellipsometry Methods.

**Suggested readings specific to the Module II**

2.1 T2 (Chapter 2, Section 1), 2.2 T2 (Chapter 2, Section 2.2), 2.3 T2 (Chapter 2, Section 2.2), 2.4 T2 (Chapter 2, Section 3), 2.5 T2 (Chapter 2, Section 4), 2.6 T (), 2.7 T2 (Chapter 2, Section 4.4), 2.8 T (), 2.9 T2 (Chapter 3, Section 1), 2.10 T2 (Chapter 3, Section 1.1), 2.11 T2 (Chapter 3, Section 1.2), 2.12 T2 (Chapter 3, Section 1.5).

**Module III**

3.1 Characterization/Analysis of Materials and Devices (Basic Principles), 3.2 X-Ray Diffraction (XRD), 3.3 Transmission Electron Microscopy (TEM), 3.4 Scanning Electron Microscopy (SEM), 3.5 Energy Dispersive Analysis of X-rays (EDAX), 3.6 UV-VIS Spectroscopy, 3.7 Fourier Transform Infrared (FTIR) Spectroscopy, 3.8

Electron Spin Resonance (ESR), 3.9 X-ray Photoelectron Spectroscopy (XPS), 3.10 Scanning Tunneling Microscopy (STM), 3.11 Atomic Force Microscopy (AFM), 3.12 Applications: Thin film resistors, 3.13 Materials and Design of thin film resistors (Choice of resistor and shape and area), 3.14 Trimming of Thin Film resistors, 3.15 Sheet Resistance Control, 3.16 Individual Resistor Trimming, 3.17 Thin Film Capacitors, 3.18 Thin Film Field Transistors, 3.19 Fabrication and Characteristics, 3.20 Thin Film Diodes.

**Suggested readings specific to the Module III**

3.1 T (), 3.2 T, 3.3 T, 3.4 T, 3.5 T, 3.6 T, 3.7 T, 3.8 T, 3.9 T, 3.10 T, 3.11 T, 3.12 T1 (Chapter 18, Section 2), 3.13 T1 (Chapter 18, Section 3), 3.14 T1 (Chapter 18, Section 4), 3.15 T1 (Chapter 18, Section 4a), 3.16 T1 (Chapter 18, Section 4c), 3.17 T1 (Chapter 19, Section 1), 3.18 T1 (Chapter 19, Section 1a), 3.19 T1 (Chapter 19, Section 1a), 3.20 T1 (Chapter 19, Section 1b).

## TEACHING LEARNING STRATEGIES

Developing conceptual understanding, using visual aids and real-world applications, emphasizing problem-solving skills, promoting active learning.

## MODE OF TRANSACTION

Lectures, seminars, discussions, and demonstrations.

## ASSESSMENT RUBRICS

| **Description** | **Marks** |
|---|---|
| **End Semester Evaluation** | **60** |
| **Continuous Evaluation** | **40** |
| • Assignments | 8 |
| • Internal tests | 16 |
| • Seminar | 6 |
| • Viva | 10 |

## MSPHY04DSE14: LASERS, NONLINEAR OPTICS, AND FIBER OPTICS

## COURSE CONTENTS

**Objectives:** The main objectives of the course are to study theory, construction, working and different applications of Lasers. Also, understanding the theory, construction, working and different application of optical fibers. This course also covers nonlinear optical phenomena like second harmonic generation, parametric amplification, self-focusing etc. Another important objective of this course is detailed study of modern optics phenomena like multiple beam interference, different types of diffraction, optical activities and nanophotonics.

| Credit | | | Teaching Hours | | | Assessment | | |
|---|---|---|---|---|---|---|---|---|
| L/T | P/I | Total | L/T | P/I | Total | CE | ESE | Total |
| 3 | - | 3 | 5 | - | 5 | 40 | 60 | 100 |

**Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation**

COURSE OUTCOMES

**Course Learning Outcomes: At the end of the Course, the Student will be able to –**

| | |
|---|---|
| **C01** | Explain the basics of LASER, the working principle of different varieties of LASERS, and their applications. |
| **C02** | Describe the propagation of light through optical fiber, the relation between Numerical Aperture and Refractive indices, the types of optical fibers, and the attenuation mechanism. |
| **C03** | Illustrate nonlinear optics and explain the Harmonic generation, parametric amplification etc. |

## COURSE CONTENTS

**Module I**

1.1 Lasers: Introduction, 1.2 Properties of Lasers: Intensity, Monochromaticity, Directionality and Coherence, 1.3 Einstein's Coefficients, 1.4 Gain Coefficient, 1.5 Concept of Population Inversion, 1.6 Line Broadening Mechanisms: Natural, Collision and Doppler Broadening, 1.7 Rate Equations: Three Level and Four Level Systems, 1.8 Temporal Coherence and Spatial Coherence, 1.9 Ruby Laser, 1.10 Argon-Ion Laser, 1.11 CO2 Laser, 1.12 Dye Laser, 1.13 Semiconductor Laser, 1.14 Spatial Frequency and Holography, 1.15 Laser Induced Fusion.

**Suggested readings specific to the module.**

1.1 William T Silfvast (Section 1), 1.2 Laud B. B (Section 1), 1.3 Laud B. B (Section 2.1) Ghatak and Thyagarajan, Optical Electronics (Section 8.2), 1.4 William T Silfvast (Section 7.1), 1.5 Laud B. B (Section 6.1), William T Silfvast (Section 7.2)1.6 Laud B. B (Section 5.8)Ghatak and Thyagarajan, Optical Electronics (Sections 8.8), William T

Silfvast (Section 7.4)1.7 William T Silfvast (Section 9.3)Ghatak and Thyagarajan, Optical Electronics (Section 8.5), 1.8 William T Silfvast (Section 2.4)G.R.Fowles (Section 3.7), 1.9 Laud B. B (Section 7.1)William T Silfvast (Section 15.2)G.R.Fowles (Section 9.8)Ghatak and Thyagarajan, Optical Electronics (Sections 10.2), 1.10 Laud B. B (Section 8.3.1)William T Silfvast (Section 14.1) Ghatak and Thyagarajan, Optical Electronics (Sections 10.5), 1.11 Laud B. B (Section 8.5.1)William T Silfvast (Section 14.2) Ghatak and Thyagarajan, Optical Electronics (Sections 10.6), 1.12 Laud B. B (Section 10.2)William T Silfvast (Section 15.1)G.R.Fowles (Section 9.9)Ghatak and Thyagarajan, Optical Electronics (Sections 10.7), 1.13 Laud B. B (Section 9)William T Silfvast (Section 15.3)G.R.Fowles (Section 9.10) Ghatak and Thyagarajan, Optical Electronics (Sections 10.9), 1.14 Laud B. B (Section 12)Ghatak and Thyagarajan, Optical Electronics (Section 6,7)

**Module II**

2.1 Fibre Optics: Introduction, 2.2 Fibre Optics Communication System, 2.3 Advantages of Fibre Optics Systems, 2.4 Ray Propagation in Step-Index Fibres, 2.5 Ray Propagation in Graded Index Fibres, 2.6 Effect of Material Dispersion, 2.7 The Combined Effect of Multipath and Material Dispersion, 2.8 Calculation of rms Pulse Width, 2.9 Single Mode Fibres (SMF), 2.10 Characteristic Parameters of SMFs, 2.11 Dispersion in Single Mode Fibres.

**Suggested readings specific to the module.**

2.1 R. P. Khare (Section 1.1,1.2)Ghatak and Thyagarajan, Optical Electronics (Sections 13.1,13.2), 2.2 R. P. Khare (Section 1.3)2.3 R. P. Khare (Section 1.4), 2.4 R. P. Khare (Section 2.3)Ghatak and Thyagarajan, Optical Electronics (Sections 13.6), 2.5 R. P. Khare (Section 2.4)Ghatak and Thyagarajan, Optical Electronics (Sections 13.7), 2.6 R. P. Khare (Section 2.5), 2.7 R. P. Khare (Section 2.6), 2.8 R. P. Khare (Section 2.7), 2.9 R. P. Khare (Section 5.1,5.2)Ghatak and Thyagarajan, Optical Electronics (Sections 13.11), 2.10 R. P. Khare (Section 5.3), 2.11 R. P. Khare (Section 5.4)

**Module III**

3.1 Nonlinear Optics: Harmonic generation, 3.2 Second harmonic generation, 3.3 Phase matching, 3.4 Third harmonic generation, 3.5 Optical mixing, 3.6 Parametric generation of light, 3.7 Self focusing, 3.8 Multi quantum photoelectric effect, 3.9 Two photon process and theory, 3.10 Multi photon processes, 3.11 Three photon processes, 3.12 Second harmonic generation, 3.13 Parametric generation of light.

**Suggested readings specific to the module.**

3.1 Laud B. B (Section 13.1)Ghatak and Thyagarajan, Optical Electronics (Sections 20.3), 3.2 Laud B. B (Section 13.2)William T Silfvast (Section 16.3)Ghatak and Thyagarajan, Optical Electronics (Sections 20.3), 3.3 Laud B. B (Section 13.3)William T Silfvast (Section 16.6), 3.4 Laud B. B (Section 13.4)William T Silfvast

(Section 16.4), 3.5 Laud B. B (Section 13.5), 3.6 Laud B. B (Section 13.6), 3.7 Laud B. B (Section 13.7)William T Silfvast (Section 16.4), Ghatak and Thyagarajan, Optical Electronics (Sections 20.2)3.8 Laud B. B (Section 14.1), 3.9 Laud B. B (Section 14.2,14.3)William T Silfvast (Section 16.8), 3.10 Laud B. B (Section 14.7), 3.11 Laud B. B (Section 14.8), 3.12 Laud B. B (Section 14.9), 3.13 Laud B. B (Section 14.10)

## MSPHY04DSE15: ADVANCED MATERIALS CHARACTERIZATION TECHNIQUES

**Module I**

Basics of Crystallography: crystal systems, interplanar spacings, planes of a form, planes of a zone.

**Module II**

XRD Techniques: Basics of X-Rays: generation, absorption, filtering, diffraction, diffracted intensity, XRD methods, Powder method: Specimen preparation, Selection of radiation, Background radiation, Determination of Crystal structure, lattice parameter, Chemical analysis, Particle size, Stereographic projections: Determination of texture.

**Module III**

TEM: Electron optics, image formation, Theories of contrast in crystals, electron diffraction, indexing SAD patterns, specimen preparation. SEM: Electron-specimen interaction, signals, modes of working, Field ion and field emission microscopes.

**Core Compulsory Readings:**


1. B. D. Cullity, "Elements of X-ray Diffraction", Addison-Wesley Publishing Company Inc, 1978.
2. K Ramakanth Hebbar, "Basics of X-ray Diffraction and its applications", I K International, New Delhi, 2007
3. P. E. J. Flewitt& R. K. Wild, "Physical Methods of Materials Characterization", IOP, 1994
4. P. G. Grundy and G. A. Jones, "Electron microscopy in study of Materials", Hodder Arnold, 1976
5. J. I Goldstein, "Scanning Electron Microscopy and X-Ray Microanalysis", Springer, 2003