

# DEPARTMENT OF PHYSICS

SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)  
(FIRST – EIGHT SEMESTER)

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ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)

ARYA NAGAR, GUWAHATI – 16

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# **PREFACE**

**“Education is not preparation for life; education is life itself.” —John Dewey**

The aim of imparting education is not only to increase the knowledge but also to create the possibilities for a student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) - the spirit of NEP, 2020. The programmes offered by the college are:

- i. Bachelor Degree in Arts
- ii. Bachelor Degree in Science
- iii. Bachelor Degree in Commerce

Under the above programme, the following courses are offered by the college:

- i. Core Course
- ii. Minor Course
- iii. Skill Enhancement Course
- iv. Interdisciplinary Course
- v. Ability Enhancement Course
- vi. Value Added Course
- vii. Internship

Programme outcome of each programme and Programme Specific Outcomes of each discipline/subject offered by the college is mapped with course learning outcome of each course. Graduate attributes of students obtaining Undergraduate Degree from the college are also incorporated in the syllabus.

The syllabus includes eight semesters where there will be 23 Core Courses, 8 Minor Courses, 2 Value Added Courses, 3 SEC Courses, 3 IDC Courses, 4 AEC courses and internship. The total credit offered for eight semesters is 160.

The syllabus framed takes into account the different styles of learning – audio, visual and experiential. The syllabus correlates academics to real life situations balancing social and emotional stimulation among the students and imbibe human values. Also the syllabus gives the opportunity for the theoretical knowledge to be pursued ensuring maximum application of it.

## Structure of Four Year Undergraduate Course

| Semester | Type   | Core                                                         | Minor   | SEC     | IDC     | AEC     | VAC/FC                   | IN      |
|----------|--------|--------------------------------------------------------------|---------|---------|---------|---------|--------------------------|---------|
|          | Credit | 4                                                            | 4       | 3       | 3       | 2       | 4(2 + 2)                 | 2       |
| I        |        | CE-1114                                                      | MN-1114 | SE-1113 | ID-1113 | AE-1112 | VL-1112<br>(Two Courses) | -       |
| II       |        | CE-2114                                                      | MN-2114 | SE-2113 | ID-2113 | AE-2112 | VL-2112<br>(Two Courses) | -       |
| III      |        | CE-3214<br>CE-3224                                           | MN-3214 | SE-3213 | ID-3213 | AE-3212 | -                        | -       |
| IV       |        | CE-4214<br>CE-4224<br>CE-4234                                | MN-4214 | -       | -       | AE-4212 | -                        | IN-4212 |
| V        |        | CE-5314<br>CE-5324<br>CE-5334<br>CE-5344                     | MN-5214 | -       | -       | -       | -                        | -       |
| VI       |        | CE-6314<br>CE-6324<br>CE-6334<br>CE-6344                     | MN-6214 | -       | -       | -       | -                        | -       |
| VII      |        | CE-7414*<br>CE-7424**<br>CE-7434**<br>CE-7444**<br>CE-7454** | MN-7314 | -       | -       | -       | -                        | -       |
| VIII     |        | CE-8414#<br>CE-8424#<br>CE-8434#<br>CE-8444#<br>CE-8454#     | MN-8314 | -       | -       | -       | -                        | -       |

\*Compulsory for all students in the 7<sup>th</sup> semester.

\*\*Students are required to choose any three courses from the remaining four core courses in the 7<sup>th</sup> semesters.

# Students who wish to pursue a Bachelor Degree with Honours must choose any four of the five core courses in the 8<sup>th</sup> semester.

NOTE: Students who secure a minimum of 7.5 CGPA at the end of the 6<sup>th</sup> semester (without any arrears) may opt for a Bachelor Degree with Honours and Research. Those students shall have to choose one core course out of the given five courses in the 8<sup>th</sup> semester and have to complete a Research Dissertation of 12 credits.

Course code: First two letters is the abbreviation of course component  
 First digit implies semester number  
 Second digit implies course level  
 Third digit implies course number  
 Fourth digit implies credit points per course.

| Digit | Course Level |
|-------|--------------|
| 1     | 100 - 199    |
| 2     | 200 - 299    |
| 3     | 300 - 399    |
| 4     | 400 - 499    |

### Semester Wise Credit Distribution

| Semester | CREDIT DISTRIBUTION |       |       |       |       |        |       |       |
|----------|---------------------|-------|-------|-------|-------|--------|-------|-------|
|          | CORE                | MINOR | SEC   | AEC   | IDC   | VAC/FC | IN    | TOTAL |
| FIRST    | 1 x 4               | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | 2 x 2  | --    | 20    |
| SECOND   | 1 x 4               | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | 2 x 2  | --    | 20    |
| THIRD    | 2 x 4               | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | --     | --    | 20    |
| FOURTH   | 3 x 4               | 1 x 4 | --    | 1 x 2 | --    | --     | 1 x 2 | 20    |
| FIFTH    | 4 x 4               | 1 x 4 | --    | --    | --    | --     | --    | 20    |
| SIXTH    | 4 x 4               | 1 x 4 | --    | --    | --    | --     | --    | 20    |
| SEVENTH  | 4 x 4               | 1 x 4 | --    | --    | --    | --     | --    | 20    |
| EIGHT    | 4 x 4               | 1 x 4 | --    | --    | --    | --     | --    | 20    |

**SEC: SKILL ENHANCEMENT COURSE**

**AEC: ABILITY ENHANCEMENT COURSE**

**IDC: INTERDISCIPLINARY COURSE**

**VAC/FC: VALUE ADDED COURSE**

**IN: INTERNSHIP**

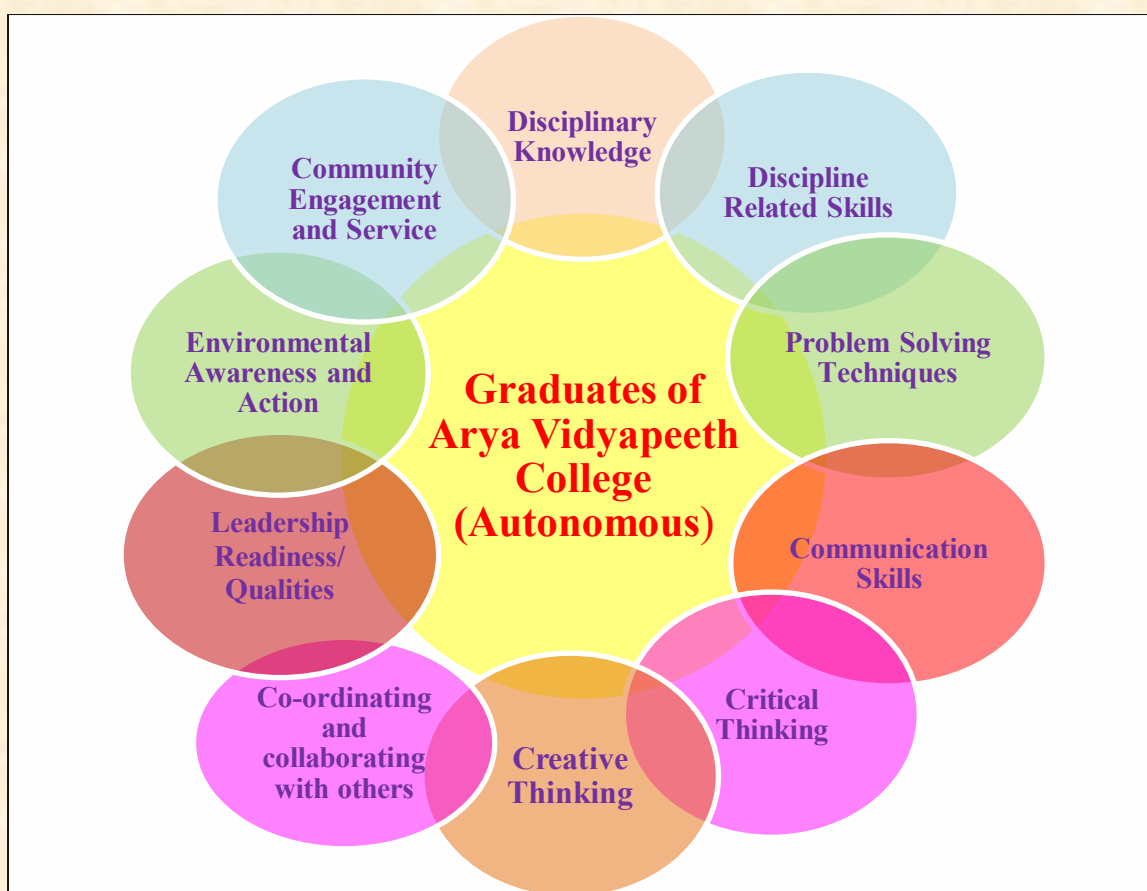
**Abbreviation of Course Components:**

**CE (Core), MN (Minor), SE (Skill Enhancement Course), AE (Ability Enhancement Course),  
VL (Value added Course), ID (Interdisciplinary Course), IN (Internship)**

## GRADUATE ATTRIBUTES

### Graduate Attributes:

Graduate Attributes are the qualities, skills and understandings that the students should develop during their time with the college. These attributes consequently shape the contribution they are able to make to their profession and society. They are the qualities that also prepare graduates as agents of social good in an unknown future. These attributes sets them apart from those without a degree. The graduate attributes of Arya Vidyapeeth College (Autonomous) are:



**Model of Graduate Attributes**

1. **Disciplinary knowledge:** Graduates shall acquire comprehensive knowledge and understanding of their subject area, the ability to engage with different traditions of thought, and the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
2. **Discipline related skills:** Skills in areas related to specialization in the chosen disciplinary/interdisciplinary/major/minor area(s) of learning in a broad multidisciplinary context. In addition create, select, and apply appropriate modern techniques, resources and IT tools.
3. **Problem solving skills:** A capacity for problem identification, the collection of evidence, synthesis and dispassionate analysis and apply one's learning in real – life situations.

4. **Communication Skills:** Ability to recognize and value communication as the tool for negotiating and creating new understanding, collaborating with others, and furthering their own learning.
5. **Critical thinking:** Graduates acquire the capacity for problem identification, collection of evidence, synthesis and dispassionate analysis. They also acquire the capacity for attentive exchange, informed argument and reasoning.
6. **Creative Thinking:** The graduates acquire an ability to create, perform or think in different and diverse ways about the same objects or scenarios and also the ability to communicate effectively for different purposes and in different contexts. They should also be able to work independently and as part of a team.
7. **Co-ordinating and collaborating with others:** The graduates need to possess the ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. They should also be able to work productively with others, no matter their culture, perspective or background, and complete joint projects and also to work in partnership.
8. **Leadership readiness/qualities:** The graduates should be able to lead and support others by inspiring them with a clear vision and motivating them to achieve goals. They also need to acquire ability to map out the tasks of a team or an organization and setting directions.
9. **Environmental Awareness and action:** The graduates shall earn the capacity to realize the individual's responsibility in protecting and conserving the environment. They need to gain the capacity to understand the impact of the professional solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
10. **Community engagement and service:** The graduates need to develop an understanding of social and civic responsibilities, and of the rights of individuals and groups. The graduates should be able to demonstrate the capability to participate in community-engaged services/ activities for promoting the wellbeing of the society which includes participation in NSS, NCC, adult literacy etc

## **UNDERGRADUATE PROGRAMME OUTCOME (PO)**

### **BACHELOR DEGREE IN SCIENCE: (B.Sc.)**

1. **SPO-1 Knowledge:** Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.
2. **SPO-2 Problem Analyses:** Well, equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyze results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and sciences.
3. **SPO-3 Designing Solutions:** Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.
4. **SPO-4 Modern tool usage:** Learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).
5. **SPO-5 Effective Communication:** Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.
6. **SPO-6 Employability:** This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations
7. **SPO-7 Ethics:** While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economic and environmental issues. One of the main objectives of any academic exercise,

therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As such, at the end of this programme students will be able to develop, internalise and exercise ethics in their professional as well as personal practices.

8. **SPO-8 Environment and Sustainability:** ‘Environmental sustainability’ has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyze socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.
9. **SPO-9 Soft-Skill Development:** Apart from the attainment of knowledge and hands on skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.
10. **SPO-10 Science and Society:** The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.
11. **SPO-11 Life-long learning:** With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competitiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

# CORE

**LIST OF COURSES:**

| Semester | COURSE Name & Code                                                 | Contents                                    |
|----------|--------------------------------------------------------------------|---------------------------------------------|
| 1        | MATHEMATICAL PHYSICS-I<br>&<br>MECHANICS-I<br>PY-CE-1114           | Vectors and scalars                         |
|          |                                                                    | Vector differentiation                      |
|          |                                                                    | Vector differential operator                |
|          |                                                                    | Vector Integration                          |
|          |                                                                    | Work energy principle                       |
|          |                                                                    | Rigid body dynamics                         |
|          |                                                                    | Gravitation                                 |
|          |                                                                    | Special theory of relativity.               |
| 2        | MATHEMATICAL PHYSICS-II<br>&<br>PROPERTIES OF MATTER<br>PY-CE-2114 | Ordinary Differential Equation              |
|          |                                                                    | Partial Differential Equation               |
|          |                                                                    | Elasticity                                  |
|          |                                                                    | Surface Tension                             |
|          |                                                                    | Viscosity.                                  |
| 3        | MATHEMATICAL PHYSICS-III<br>PY-CE-3214                             | Orthogonal Curvilinear Coordinate           |
|          |                                                                    | Matrix Algebra                              |
|          |                                                                    | Dirac Delta Function                        |
|          |                                                                    | Some Special Integrals                      |
|          |                                                                    | Theory of Probability and Errors            |
|          | OPTICS<br>PY-CE-3224                                               | Ray Optics                                  |
|          |                                                                    | Wave Optics.                                |
| 4        | MATHEMATICAL PHYSICS-IV<br>PY-CE-4214                              | Series Solution of Differential Equation    |
|          |                                                                    | Fourier Series                              |
|          |                                                                    | Tensor Analysis                             |
|          |                                                                    | Solution of Linear and Non-linear Equations |
|          |                                                                    | Numerical Integration                       |
|          | WAVES & APPLIED OPTICS<br>PY-CE-4224                               | Harmonic Motion                             |
|          |                                                                    | Wave Motion                                 |
|          |                                                                    | Sound Wave                                  |
|          |                                                                    | Superposition of Two Harmonic Waves         |
|          |                                                                    | Applied Optics                              |
|          |                                                                    | Electrostatics                              |

|   |                                         |                                                                                        |
|---|-----------------------------------------|----------------------------------------------------------------------------------------|
| 4 | ELECTRICITY AND MAGNETISM<br>PY-CE-4234 | Current Electricity                                                                    |
|   |                                         | Magnetostatics                                                                         |
| 5 | MATHEMATICAL PHYSICS-V<br>PY-CE-5314    | Complex Analysis                                                                       |
|   |                                         | Complex Integration                                                                    |
|   |                                         | Fourier Transformation                                                                 |
|   |                                         | Laplace Transformation                                                                 |
|   |                                         | Numerical Solution of Ordinary Differential Equation and Partial differential Equation |
|   | CLASSICAL MECHANICS<br>PY-CE-5324       | D'Alembert's Principle and Lagrangian Equation                                         |
|   |                                         | Hamiltonian Dynamics and Poisson Bracket                                               |
|   |                                         | Motion under Central Force and theory of Scattering                                    |
|   |                                         | Relativistic Mechanics                                                                 |
|   | THERMAL PHYSICS<br>PY-CE-5334           | Zeroth and First Law of Thermodynamics                                                 |
|   |                                         | Second Law of Thermodynamics                                                           |
|   |                                         | Entropy                                                                                |
|   |                                         | Thermodynamic Potentials                                                               |
|   |                                         | Maxwell's Thermodynamic Relations                                                      |
|   |                                         | Distribution of Velocities                                                             |
|   |                                         | Molecular Collisions                                                                   |
|   |                                         | Real Gases.                                                                            |
|   | ANALOG ELECTRONICS<br>PY – CE – 5344    | Semiconductor devices                                                                  |
|   |                                         | Network Theorem                                                                        |
|   |                                         | Bipolar Junction Transistors                                                           |
|   |                                         | Two-terminal Devices and their Applications                                            |
|   |                                         | Sinusoidal Oscillators                                                                 |
|   |                                         | Operational Amplifiers (Black Box approach)                                            |
|   | QUANTUM MECHANICS<br>PY-CE-6314         | Origin of Quantum Theory                                                               |
|   |                                         | Schrödinger Equation                                                                   |
|   |                                         | Postulates of Quantum Mechanics                                                        |
|   |                                         | Application of Schrödinger Equation .                                                  |
|   |                                         | Crystal Structure                                                                      |

|                                     |                                                   |                                                       |
|-------------------------------------|---------------------------------------------------|-------------------------------------------------------|
| 6                                   | CONDENSED MATTER<br>PHYSICS<br>PY-CE-6324         | Crystal Bonding                                       |
|                                     |                                                   | Free electron theory of metals                        |
|                                     |                                                   | Specific Heat of Solids                               |
|                                     |                                                   | Dielectric and Ferroelectric Properties of materials  |
|                                     | ATOMIC AND NUCLEAR<br>PHYSICS<br>PY-CE-6334       | Discovery of charged particles                        |
|                                     |                                                   | X-Rays                                                |
|                                     |                                                   | Atoms in Electric and Magnetic Fields                 |
|                                     |                                                   | General properties of atomic nuclei and its stability |
|                                     |                                                   | Radioactive Decay                                     |
|                                     | DIGITAL ELECTRONICS<br><br>PY-CE-6344             | Integrated Circuits                                   |
|                                     |                                                   | Digital Circuits                                      |
|                                     |                                                   | Boolean Algebra                                       |
|                                     |                                                   | Arithmetic Circuits                                   |
|                                     |                                                   | Sequential Circuits                                   |
|                                     |                                                   | Timer Circuits                                        |
| Shift Registers (up to 4-bits only) |                                                   |                                                       |
| Counters (up to 4-bits only)        |                                                   |                                                       |
| Computer Organization               |                                                   |                                                       |
| 7                                   | RESEARCH METHODOLOGY IN PHYSICS<br><br>PY-CE-7414 | Introduction to Research methodology                  |
|                                     |                                                   | Literature Survey and Research Ethics                 |
|                                     |                                                   | Scientific Research Presentations                     |
|                                     |                                                   | Data Interpretation and Analysis in Physics           |
|                                     | ELECTROMAGNETIC THEORY<br><br>PY-CE-7424          | Maxwell Equations                                     |
|                                     |                                                   | EM Wave Propagation in Unbounded Media                |
|                                     |                                                   | EM Waves in Bounded Media                             |
|                                     |                                                   | Polarization of EM Waves                              |
|                                     |                                                   | Wave Guides                                           |
|                                     | ADVANCED CLASSICAL MECHANICS<br><br>PY-CE-7434    | Canonical transformation and Hamilton-Jacobi theory   |
|                                     |                                                   | Small oscillations                                    |
|                                     |                                                   | Theory of scattering                                  |

|   |                                                      |                                                |
|---|------------------------------------------------------|------------------------------------------------|
| 7 |                                                      | Rigid Body Dynamics                            |
|   |                                                      | Nonlinear Dynamics                             |
|   | ELECTRONICS DEVICES AND COMMUNICATIONS<br>PY-CE-7444 | Electronic Devices                             |
|   |                                                      | Phase Locked Loop (PLL)                        |
|   |                                                      | Electronic Communication Systems and Processes |
|   | ATOMIC & MOLECULAR SPECTROSCOPY<br>PY-CE-7454        | Atomic Physics                                 |
|   |                                                      | Molecular Structure                            |
|   |                                                      | Molecular Spectra                              |
| 8 | ADVANCED QUANTUM MECHANICS<br>PY-CE-8414             | Mathematical Prerequisites                     |
|   |                                                      | Quantum Dynamics                               |
|   |                                                      | Angular Momentum                               |
|   |                                                      | Approximation Methods                          |
|   | STATISTICAL MECHANICS<br>PY-CE-8424                  | Classical Statistics                           |
|   |                                                      | Classical Theory of Radiation                  |
|   |                                                      | Quantum Theory of Radiation                    |
|   |                                                      | Bose-Einstein Statistics                       |
|   |                                                      | Fermi-Dirac Statistics                         |
|   | ADVANCED CONDENSED MATTER PHYSICS<br>PY-CE-8434      | Lattice Dynamics                               |
|   |                                                      | Imperfections in Crystalline Solids            |
|   |                                                      | Nanomaterials                                  |
|   |                                                      | Magnetism in Solids                            |
|   |                                                      | Superconductivity                              |
|   | ADVANCED NUCLEAR PHYSICS<br>PY-CE-8444               | Nuclear Models                                 |
|   |                                                      | Nuclear Reactions                              |
|   |                                                      | Forces between Nucleons                        |
|   |                                                      | Nuclear Detectors                              |
|   |                                                      | Nuclear Accelerators                           |
|   |                                                      | Elementary Particles                           |
|   | ASTRONOMY & ASTROPHYSICS<br>PY-CE-8454               | Basic Astronomy                                |
|   |                                                      | Positional Astronomy                           |
|   |                                                      | Astronomical Techniques                        |

|   |                           |                        |
|---|---------------------------|------------------------|
| 8 |                           | Stellar Astrophysics   |
|   |                           | Solar System Objects   |
|   |                           | Galaxies and Cosmology |
|   | Dissertation<br>PY-DT-812 |                        |

### Programme Specific Outcome of Bachelor of Science-Physics Core (PSO)

| PSO No. | Name                                          | Outcome                                                                                                                                                                                                                                                                                                                                                             |
|---------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PSO-1   | Basic Knowledge                               | The learner will acquire knowledge regarding the fundamental principles of Physics through the study of Mechanics, Optics, Waves and Oscillation, Heat and Thermodynamics, Electricity and Magnetism, Classical Mechanics, Quantum Mechanics, Atomic and Nuclear Physics, Electronics, Statistical Mechanics, and Electromagnetic Theory.                           |
| PSO-2   | Research Level Competency & Critical Thinking | The learner will be familiar with the state of the art of the appropriate level of technology for (a) experimental design and implementation, (b) analysis of experimental data, (c) numerical and mathematical methods in solving problems, (d) different computational techniques and apply them for experimental data analysis and solving theoretical problems. |
| PSO-3   | Skill Enhancement through ICT                 | The learner will acquire a fair amount of computational skills using open-source software packages such as Python, Numpy, Scipy, Matplotlib, Matlab, and LaTeX. This will not only prepare them for higher studies or research in any branch of Physics but also make them ready for various kinds of jobs in the IT sector and other industries.                   |
| PSO-4   | Communication Skill                           | The learner will learn effective communication skills to present their knowledge of physics from basic to advanced levels in the form of preparation of laboratory notebooks, project work, seminar presentations, poster presentations, wall magazines, models and other modes.                                                                                    |
| PSO-5   | Digitally Efficient                           | The learner will learn using computers for computational and simulation studies in Physics. Proficiency will be earned in appropriate soft-ware for numerical and statistical analysis of data, ability to search information related to Physics from internet.                                                                                                     |
| PSO-6   | Team Work                                     | The learner will learn to work either independently or in a group during laboratory sessions, projects and student seminar.                                                                                                                                                                                                                                         |
| PSO-7   | R & D Jobs                                    | The learner can pursue a career in R & D jobs related to Physics and allied fields like Space Physics, Atmospheric Physics, Instrumentation, Oceanography and lots more.                                                                                                                                                                                            |
| PSO-8   | Competency for Competitive Examinations       | The learner will be competent to face national/international level examinations like UGC-CSIR NET, GATE, JAM, JEST, GRE, TOEFL and UPSC Civil Service Examinations.                                                                                                                                                                                                 |

Course Learning Outcome (CLO) – Core

| Semester | Course Name & Code                                           | Course Learning Outcome (CLO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------|--------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | MATHEMATICAL PHYSICS-I & MECHANICS-I<br>PY-CE-1114           | CLO-01                        | After completing the course a student will be able to understand vector and their applications in various fields.                                                                                                                                                                                                                                                                                                                                                                                       |
|          |                                                              | CLO-02                        | Further, a student will be able to understand and solve a real-life problem that needs an understanding of the laws of mechanics, gravitation, and relativity.                                                                                                                                                                                                                                                                                                                                          |
| 2        | MATHEMATICAL PHYSICS-II & PROPERTIES OF MATTER<br>PY-CE-2114 | CLO-01                        | After completing the course, a student will be able to solve ordinary as well as partial differential equations. They can apply the knowledge in various fields of science and engineering fields.                                                                                                                                                                                                                                                                                                      |
|          |                                                              | CLO-02                        | Further, a student will be able to understand and solve a real-life problem that needs an understanding of the elasticity, surface tension and viscosity.                                                                                                                                                                                                                                                                                                                                               |
| 3        | MATHEMATICAL PHYSICS-III<br>PY-CE-3214                       | CLO - 01                      | After successful completion of the course, the learner will learn about generalized coordinate system and its transformation to other coordinate system like Cartesian, polar, cylindrical, and spherical polar coordinate system; Matrix algebra, determination of eigen values and eigen vectors, etc.; Randomness of event and theory of probability; The method of error calculation and its minimisation.                                                                                          |
|          |                                                              | CLO-02                        | The learner can apply the knowledge of coordinate system and its transformation in different field of science and engineering. The application of matrix is wide not only in Physics but also indifferent branches of science and technology. The knowledge of matrix will help in understanding and solving problems. The knowledge of error calculation and its minimisation, and also, fitting of experimental data by the method of least square can be applied indifferent experimental procedure. |

|   |                                        |        |                                                                                                                                                                                                                                                                                             |
|---|----------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3 | MATHEMATICAL PHYSICS-III<br>PY-CE-3214 | CLO-03 | Any real-life problem can be analyzed and may be given a matrix representation which is a most common procedure in science and technology. The learner can apply the knowledge of matrix in solving a real-life problem. Similar is the case with knowledge of error theory and probability |
|   | OPTICS<br>PY-CE-3224                   | CLO-01 | After successful completion of the course, a learner will learn about formation of image due to a system of lenses, different types of magnifications, defects of images of different types, and matrix method of studying geometrical optics.                                              |
|   |                                        | CLO-02 | Also, the learner will learn about detailed theory of wave like behavior of light through the phenomena interference, diffraction, and polarisation as well as associated phenomena - colour of thin film, Newton's ring etc.                                                               |
|   |                                        | CLO-03 | Biprism experiment, Newton's ring experiment, Michelson Interferometer, Grating experiment, experiment with polarimeter will give better insight into the subject.                                                                                                                          |
| 4 | MATHEMATICAL PHYSICS-IV<br>PY-CE-4214  | CLO-1  | After successful completion of the course, a learner will receive broad overview of solving differential equation by series method. Similarly, they will be acquainted with other mathematical tools like Dirac-Delta function, Beta-Gamma function and Tensor analysis                     |
|   |                                        | CLO-02 | These mathematical tools have extensive applications in the field of Quantum Mechanics, General Theory of Relativity and many more.                                                                                                                                                         |
|   |                                        | CLO-03 | These knowledge will help a learner in solving problems related to Quantum Mechanics, General Theory of Relativity etc.                                                                                                                                                                     |
|   | WAVES & APPLIED OPTICS<br>PY-CE-4224   | CLO-01 | This course will acquaint the learner with the oscillatory motion of simple harmonic type and its classification under different physical conditions; phenomenon like resonance. They will learn about wave motion in an elastic medium and its mathematical analysis                       |
|   |                                        | CLO-02 | Also, they will learn about propagation of sound in an elastic medium, Newton's formula to determine the velocity of sound and Laplace correction. Fourier analysis of sound wave will also be learned in this course                                                                       |

|   |                                         |        |                                                                                                                                                                                                                                                                             |
|---|-----------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4 | WAVES & APPLIED OPTICS<br>PY-CE-4224    | CLO-03 | After the course, the student will learn to handle practical instruments with laser, learn holography and fibre optics.                                                                                                                                                     |
|   |                                         | CLO-04 | This course will help in understanding musical notes and working of the musical instruments; necessary criteria for constructing an auditorium etc                                                                                                                          |
|   | ELECTRICITY AND MAGNETISM<br>PY-CE-4234 | CLO-01 | One will learn the fundamental properties of charged particles and electric fields in this course.                                                                                                                                                                          |
|   |                                         | CLO-02 | This course will give learners an understanding of the phenomena of electricity, magnetism, electromagnetic Induction and electrical circuits which are essential for higher studies in physics and also important for various engineering applications.                    |
|   |                                         | CLO-03 | This course builds the basis for studying more advanced topics in electromagnetic theory.                                                                                                                                                                                   |
| 5 | MATHEMATICAL PHYSICS-V<br>PY-CE-5314    | CLO-01 | After successful completion of the course, the learner will learn about Complex Analysis and Complex Integration. They will also learn Fourier and Laplace transformation.                                                                                                  |
|   |                                         | CLO-02 | These mathematical tools will help the learner to study various branches of science and engineering. This knowledge will help the future study as well                                                                                                                      |
|   | CLASSICAL MECHANICS<br>PY-CE-5324       | CLO-01 | Understand the fundamental concepts of analytical mechanics such as generalized coordinates and velocity, the Lagrange and Hamilton functions.                                                                                                                              |
|   |                                         | CLO-02 | Ability to use the Lagrange and Hamilton equations to solve complex mechanical problems.                                                                                                                                                                                    |
|   |                                         | CLO-03 | Knowledge of relativistic mechanics will help learning advanced topics in Quantum Mechanics, Nuclear Physics, General Theory of Relativity etc.                                                                                                                             |
|   | THERMAL PHYSICS<br>PY-CE-5334           | CLO-01 | The basic laws of nature associated with heat and thermodynamics, the conversion of heat into work and vice-versa, principle of working of machine – carnot engine, concept of entropy, thermodynamic potentials, etc. Also, they will learn about kinetic theory of gases. |
|   |                                         | CLO-02 | They will learn to apply the concept of kinetic theory of gases to explain the real life physical phenomena like thermal conductivity, diffusion of gases in a medium, phenomenon like Brownian motion, etc.                                                                |

|   |                                             |        |                                                                                                                                                                                                                                                                                                                                                      |
|---|---------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 | ANALOG ELECTRONICS<br>PY-CE-5344            | CLO-01 | This course forms the basis of electronics which is responsible for the technological advances of the present-day world.                                                                                                                                                                                                                             |
|   |                                             | CLO-02 | The learner will understand the basic concepts of semi-conductor physics and its application.                                                                                                                                                                                                                                                        |
|   |                                             | CLO-03 | They will learn about the operation, characteristics, and various applications of different types of diodes, transistors, field effect transistors, OPAMP, and oscillators.                                                                                                                                                                          |
|   |                                             | CLO-04 | They will also have an idea about the working of amplifier and regulated power supply.                                                                                                                                                                                                                                                               |
| 6 | QUANTUM MECHANICS<br>PY-CE-6314             | CLO-01 | The learner will receive a broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation which is one of the important equation for studying quantum mechanical systems will be learned along with other aspects like operator formulism of quantum mechanics, principle of uncertainty and complementary etc |
|   |                                             | CLO-02 | He will learn to apply the formulism learned so far to investigate quantum mechanical systems like simple harmonic oscillator hydrogen atom etc.                                                                                                                                                                                                     |
|   |                                             | CLO-03 | This knowledge will help in understanding other branches in Physics like Solid State Physics, Nuclear Physics, Spectroscopy etc.                                                                                                                                                                                                                     |
|   | CONDENSED MATTER<br>PHYSICS<br>PY-CE-6324   | CLO-01 | One will learn the main features of crystal lattices and understand the elementary lattice dynamics                                                                                                                                                                                                                                                  |
|   |                                             | CLO-02 | One learns about the mechanical, magnetic, and electrical properties of the substance as well as the forces that bind the units into the solid state.                                                                                                                                                                                                |
|   |                                             | CLO-03 | One also learns the main features of the physics of electrons in a solid.                                                                                                                                                                                                                                                                            |
|   |                                             | CLO-04 | Till now, the most important sub-field of solid state physics in the 20 <sup>th</sup> century is the study of semiconductors and solid state electronics. This course promises to give background knowledge in pursuing advanced-level studies in semiconductor and solid state electronics.                                                         |
|   | ATOMIC AND NUCLEAR<br>PHYSICS<br>PY-CE-6334 | CLO-01 | The learner will learn about the structure of atom and its behavior in electric and magnetic field.                                                                                                                                                                                                                                                  |

|   |                                               |        |                                                                                                                                                                                                                                 |
|---|-----------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6 | ATOMIC AND NUCLEAR PHYSICS<br>PY-CE-6334      | CLO-02 | The learner will learn the constituents of nucleus and the force which binds them together. They will learn about binding energy and understand the concept of stability of nucleus and the cause of radioactivity.             |
|   |                                               | CLO-03 | The knowledge will help them in future study and doing R&D jobs. The knowledge of nuclear physics will make them competent to pursue a career in radiological physics, nuclear power plant etc.                                 |
|   | DIGITAL ELECTRONICS<br>PY-CE-6344             | CLO-01 | At the end of the course, a learner will have a broad exposure of different types of digital circuits and their applications.                                                                                                   |
|   |                                               | CLO-02 | A learner will know the basic knowledge of integrated circuit and its types and working process of computers.                                                                                                                   |
| 7 | RESEARCH METHODOLOGY IN PHYSICS<br>PY-CE-7414 | CLO-01 | Upon completion of this course, students will be able to review literature and formulate research problems by following the research ethics.                                                                                    |
|   |                                               | CLO-02 | Upon completion of this course, students will have the proficiency in writing scientific reports/research proposals and present the research on PowerPoint or poster format in a scientific community.                          |
|   |                                               | CLO-03 | The learner will get Knowledge of software tools for data analysis and interpretation in physical sciences research.                                                                                                            |
|   |                                               | CLO-04 | Upon completion of this course, students will get basic ideas about designing a research problem and its execution in a scientific manner.                                                                                      |
|   | ELECTROMAGNETIC THEORY<br>PY-CE-7424          | CLO-01 | At the end of the course, a learner will have a broad exposure to properties of electromagnetic waves.                                                                                                                          |
|   |                                               | CLO-02 | Upon completion of this course, the student will be able to apply Maxwell's equations for different derivations for understanding the properties of electromagnetic waves.                                                      |
|   |                                               | CLO-03 | A learner will know the basic knowledge of propagation of electromagnetic waves and practical applications of electromagnetic waves.                                                                                            |
|   | ADVANCED CLASSICAL MECHANICS<br>PY-CE-7434    | CLO-01 | Upon successful completion of a Classical Mechanics course, students will be able to apply Newtonian, Lagrangian, and Hamiltonian formulations to analyse the motion of particles and rigid bodies in various physical systems. |

|   |                                                     |        |                                                                                                                                                                                                                                           |
|---|-----------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 |                                                     | CLO-02 | Students will be able to generalise the laws of physics in higher dimensions, and will be able to apply the formalism of classical mechanics to more advanced frameworks.                                                                 |
|   |                                                     | CLO-03 | Learners will also gain the ability to model real-world phenomena using mathematical tools, appreciate the limitations of classical theories, and transition smoothly into more advanced topics such as quantum mechanics and relativity. |
|   | ELECTRONIC DEVICES AND COMMUNICATIONS<br>PY-CE-7444 | CLO-01 | Upon completion of this course, students will be able to gain knowledge on advanced electronics devices such as power supply, active filters, UJT, JFET, MOSFET, PLL etc.                                                                 |
|   |                                                     | CLO-02 | After ending of this course, students will have the concepts of electronics in communication, details of communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK. |
|   |                                                     | CLO-03 | The learner will get knowledge on phase locked loop and it's applications in modern day's communication systems.                                                                                                                          |
|   |                                                     | CLO-04 | Upon completion of this course, students will get hands-on experience on working of various electronic devices and their industrial uses.                                                                                                 |
|   | ATOMIC & MOLECULAR SPECTROSCOPY<br>PY-CE-7454       | CLO-01 | Students will learn the details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models.                                                                      |
|   |                                                     | CLO-02 | It will give the descriptions of fine structure of atoms and rotational, vibrational and electronic energies of molecules manifesting in their respective spectroscopies.                                                                 |
|   |                                                     | CLO-03 | Upon completion of this course, the students will learn the details of these spectroscopies and their impact on understanding the fundamentals for various concerned experimental results.                                                |
|   |                                                     | CLO-04 | The basic principles of light coherence as laser with their types and variants will also be covered exposing the students to the important modern spectroscopic tool.                                                                     |
| 8 | ADVANCED QUANTUM MECHANICS<br>PY-CE-8414            | CLO-01 | Learning the fundamental concepts and mathematical framework of quantum mechanics.                                                                                                                                                        |
|   |                                                     | CLO-02 | Applying quantum mechanical formalisms to solve problems related to system dynamics, angular momentum,                                                                                                                                    |

|   |                                                    |        |                                                                                                                                                                                                                                               |
|---|----------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8 |                                                    |        | and approximation methods.                                                                                                                                                                                                                    |
|   |                                                    | CLO-03 | Analyse and evaluate physical systems using quantum models and interpret results in terms of observables.                                                                                                                                     |
|   | STATISTICAL MECHANICS<br>PY-CE-8424                | CLO-01 | Students would be able to understand the fundamental difference of Classical and quantum statistics and a generalized approach to study both the statistics together.                                                                         |
|   |                                                    | CLO-02 | Students will learn to evaluate and interpret the partition function and its significance in relating statistical averages to thermodynamic quantities.                                                                                       |
|   |                                                    | CLO-03 | On successful completion of the course students will be learn the techniques of Statistical Mechanics to apply in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry and in many other directions. |
|   | ADVANCED CONDENSED<br>MATTER PHYSICS<br>PY-CE-8434 | CLO-01 | This course provides a foundation for future advanced studies in solids. On successful completion of this course students will be able to learn the fundamental topics in solids such as magnetism and lattice dynamics.                      |
|   |                                                    | CLO-02 | Further the students would also be able to acquaint themselves to the nanomaterial's that bridges that the bulk and the atomic world.                                                                                                         |
|   |                                                    | CLO-03 | The learner will develop the skill to solve the experimental problems and analyse the experimental data collected from each experiment and interpret the results.                                                                             |
|   |                                                    | CLO-04 | On successful completion of the course students should be able to apply the mathematical and theoretical concepts to analyse and solve problems related to lattice dynamics, magnetic and superconducting properties.                         |
|   | ADVANCED NUCLEAR<br>PHYSICS<br>PY-CE-8444          | CLO-01 | On successful completion of the course, students will be able to understand the Basic Nuclear Properties: size, shape and charge distribution, spin, parity and isospin of nucleon and nuclei.                                                |
|   |                                                    | CLO-02 | This course provides a foundation for nuclear structure. On successful completion of this course students will be able to learn about the introductory concepts of nuclear model.                                                             |
|   |                                                    | CLO-03 | The students will learn about in-depth description of the nucleus and its different properties. They will also learn to describe the structure of the nucleus, nature of the interaction that occurs                                          |

|   |                                               |        |                                                                                                                                                                                                                                                                            |
|---|-----------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8 |                                               |        | inside the nucleus.                                                                                                                                                                                                                                                        |
|   |                                               | CLO-04 | The course will develop problem based skills and the acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry.                                                                  |
|   | ASTRONOMY &<br>ASTROPHYSICS<br><br>PY-CE-8454 | CLO-01 | Upon completion of this course, students will be able to understanding the origin and evolution of the Universe. The course will give a comprehensive idea on the measurement of requisite parameters such as astronomical scales, luminosity and astronomical quantities. |
|   |                                               | CLO-02 | On successful completion of this course, the learner will be able to apply physics of celestial objects in understanding the universe.                                                                                                                                     |
|   |                                               | CLO-03 | They will be equipped with the skills required for observational astronomy and virtual observatory tools.                                                                                                                                                                  |
|   |                                               | CLO-04 | On successful completion of the course, students will have the understanding of the solar system, origin and evolution of galaxies, presence of dark matter and large scale structures of the Universe.                                                                    |

## **MAPPING OF PROGRAMME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO)**

**Attributes:** Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

| Course Code | CLO     | Programme Outcome (PO) |       |       |       |       |       |       |       |       |        |        |
|-------------|---------|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
|             |         | SPO-1                  | SPO-2 | SPO-3 | SPO-4 | SPO-5 | SPO-6 | SPO-7 | SPO-8 | SPO-9 | SPO-10 | SPO-11 |
| PY-CE-1114  | CLO-1   | 3                      | 1     | 1     | 2     | 2     | 1     | 2     | 1     | 1     | 1      | 1      |
|             | CLO-2   | 2                      | 1     | 1     | 2     | 2     | 1     | 2     | 1     | 1     | 1      | 1      |
| PY-CE-2114  | CLO-1   | 3                      | 1     | 1     | 2     | 2     | 1     | 2     | 1     | 1     | 1      | 1      |
|             | CLO-2   | 2                      | 1     | 1     | 2     | 2     | 1     | 2     | 1     | 1     | 1      | 1      |
| PY-CE-3214  | CLO-1   | 2                      | 2     | 2     | 2     | 2     | 2     | 2     | 1     | 1     | 2      | 1      |
|             | CLO-2   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 1     | 1     | 2      | 1      |
| PY-CE-3224  | CLO-1   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 1     | 1     | 2      | 1      |
|             | CLO-2   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 1     | 1     | 2      | 1      |
| PY-CE-4214  | CLO-1   | 2                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-4224  | CLO-1   | 2                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-4234  | CLO-1   | 2                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 3                      | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-5314  | CLO-1   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 2                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-5324  | CLO-1   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-5334  | CLO-1   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 2                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-5344  | CLO - 1 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO - 2 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO - 3 | 2                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO - 4 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-6314  | CLO-1   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 2                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-6324  | CLO-1   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO-2   | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-6334  | CLO - 1 | 2                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO - 2 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-6344  | CLO - 1 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
|             | CLO - 2 | 1                      | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2     | 2      | 1      |
| PY-CE-7414  | CLO - 1 | 3                      | 3     | 3     | 3     | 3     | 3     | 3     | 3     | 2     | 2      | 1      |
|             | CLO - 2 | 3                      | 3     | 3     | 3     | 3     | 3     | 3     | 2     | 2     | 2      | 1      |
|             | CLO - 3 | 3                      | 3     | 3     | 3     | 3     | 3     | 3     | 3     | 2     | 2      | 1      |
|             | CLO - 4 | 2                      | 3     | 3     | 3     | 3     | 3     | 3     | 3     | 2     | 2      | 1      |

|            |         |   |   |   |   |   |   |   |   |   |   |   |
|------------|---------|---|---|---|---|---|---|---|---|---|---|---|
| PY-CE-7424 | CLO - 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
| PY-CE-7434 | CLO - 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| PY-CE-7444 | CLO - 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 4 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
| PY-CE-7454 | CLO - 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 |
| PY-CE-8414 | CLO - 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
| PY-CE-8424 | CLO - 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| PY-CE-8434 | CLO - 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
|            | CLO - 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
| PY-CE-8444 | CLO - 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |
|            | CLO - 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 4 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 1 |
| PY-CE-8454 | CLO - 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
|            | CLO - 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
|            | CLO - 4 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 |

## MAPPING OF PROGRAMME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOME (CLO)

**Attributes:** Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

| Course Code | CLO     | Programme Specific Outcome (PSO) |         |         |         |         |         |         |         |
|-------------|---------|----------------------------------|---------|---------|---------|---------|---------|---------|---------|
|             |         | PSO - 1                          | PSO - 2 | PSO - 3 | PSO - 4 | PSO - 5 | PSO - 6 | PSO - 7 | PSO - 8 |
| PY-CE-1114  | CLO - 1 | 3                                | 1       | 2       | 1       | 1       | 1       | 1       | 1       |
|             | CLO - 2 | 3                                | 1       | 2       | 1       | 1       | 1       | 1       | 1       |
| PY-CE-2114  | CLO - 1 | 2                                | 3       | 2       | 1       | 1       | 1       | 1       | 1       |
|             | CLO - 2 | 3                                | 1       | 2       | 1       | 1       | 1       | 1       | 1       |
| PY-CE-3214  | CLO - 1 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
|             | CLO - 2 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
| PY-CE-3224  | CLO - 1 | 2                                | 3       | 2       | 1       | 2       | 1       | 1       | 1       |
|             | CLO - 2 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
| PY-CE-4214  | CLO - 1 | 2                                | 3       | 2       | 1       | 2       | 1       | 1       | 1       |
|             | CLO - 2 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
| PY-CE-4224  | CLO - 1 | 1                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
|             | CLO - 2 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
| PY-CE-4234  | CLO - 1 | 2                                | 3       | 2       | 1       | 2       | 1       | 1       | 1       |
|             | CLO - 2 | 2                                | 2       | 2       | 1       | 2       | 1       | 1       | 1       |
| PY-CE-5314  | CLO - 1 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-5324  | CLO - 1 | 1                                | 2       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-5334  | CLO - 1 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-5344  | CLO - 1 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 3 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 4 | 1                                | 2       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-6314  | CLO - 1 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-6324  | CLO - 1 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-6334  | CLO - 1 | 1                                | 2       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-6344  | CLO - 1 | 1                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
|             | CLO - 2 | 2                                | 3       | 2       | 1       | 2       | 1       | 2       | 2       |
| PY-CE-7414  | CLO - 1 | 3                                | 3       | 3       | 3       | 2       | 3       | 3       | 3       |
|             | CLO - 2 | 3                                | 2       | 3       | 3       | 3       | 2       | 2       | 2       |
|             | CLO - 3 | 2                                | 3       | 2       | 2       | 2       | 3       | 2       | 3       |
|             | CLO - 4 | 2                                | 2       | 2       | 3       | 3       | 2       | 3       | 2       |
| PY-CE-7424  | CLO - 1 | 2                                | 3       | 2       | 3       | 2       | 2       | 3       | 2       |
|             | CLO - 2 | 3                                | 2       | 3       | 3       | 3       | 3       | 3       | 3       |
|             | CLO - 3 | 3                                | 3       | 3       | 2       | 3       | 3       | 2       | 2       |
| PY-CE-7434  | CLO - 1 | 3                                | 2       | 3       | 1       | 3       | 3       | 3       | 1       |
|             | CLO - 2 | 3                                | 2       | 3       | 2       | 1       | 3       | 1       | 3       |
|             | CLO - 3 | 2                                | 3       | 2       | 3       | 2       | 2       | 3       | 3       |
| PY-CE-7444  | CLO - 1 | 2                                | 1       | 3       | 3       | 3       | 2       | 2       | 2       |
|             | CLO - 2 | 3                                | 3       | 3       | 2       | 3       | 3       | 3       | 2       |
|             | CLO - 3 | 1                                | 1       | 3       | 2       | 2       | 1       | 2       | 3       |
|             | CLO - 4 | 3                                | 2       | 2       | 3       | 2       | 3       | 2       | 3       |
| PY-CE-7454  | CLO - 1 | 3                                | 2       | 3       | 1       | 3       | 3       | 3       | 2       |
|             | CLO - 2 | 3                                | 3       | 2       | 3       | 2       | 3       | 3       | 2       |
|             | CLO - 3 | 1                                | 1       | 3       | 1       | 3       | 1       | 3       | 2       |
| PY-CE-8414  | CLO - 1 | 2                                | 3       | 1       | 3       | 1       | 2       | 2       | 3       |
|             | CLO - 2 | 2                                | 3       | 1       | 3       | 1       | 2       | 3       | 3       |
|             | CLO - 3 | 3                                | 3       | 3       | 3       | 3       | 3       | 2       | 1       |
| PY-CE-8424  | CLO - 1 | 1                                | 2       | 2       | 2       | 3       | 1       | 2       | 3       |
|             | CLO - 2 | 3                                | 3       | 3       | 3       | 2       | 3       | 1       | 2       |

|            |         |   |   |   |   |   |   |   |   |
|------------|---------|---|---|---|---|---|---|---|---|
|            | CLO - 3 | 2 | 2 | 3 | 1 | 3 | 2 | 2 | 3 |
| PY-CE-8434 | CLO - 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 |
|            | CLO - 2 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 |
|            | CLO - 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 |
|            | CLO - 4 | 1 | 2 | 2 | 2 | 3 | 1 | 3 | 1 |
| PY-CE-8444 | CLO - 1 | 2 | 3 | 1 | 2 | 3 | 3 | 2 | 3 |
|            | CLO - 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 1 |
|            | CLO - 3 | 3 | 2 | 1 | 3 | 2 | 2 | 1 | 3 |
|            | CLO - 4 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 1 |
| PY-CE-8454 | CLO - 1 | 3 | 1 | 3 | 3 | 3 | 2 | 3 | 2 |
|            | CLO - 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
|            | CLO - 3 | 3 | 1 | 2 | 3 | 2 | 1 | 3 | 3 |
|            | CLO - 4 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 |

**COURSE NAME: Mathematical Physics - I And Mechanics - I**

**COURSE CODE: PY- CE - 1114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

### **Course Objectives:**

- *To impart advanced concepts and methods in Mathematics which include the Calculus of vector-valued functions.*
- *To impart basic concepts of work-energy principle, rigid body dynamics, laws of gravitation, and a basic concept of relativity.*

### **Course Learning Outcome:**

**CLO-01:** *After completing the course a student will be able to understand vector and their applications in various fields.*

**CLO-02:** *Further, a student will be able to understand and solve a real-life problem that needs an understanding of the laws of mechanics, gravitation, and relativity.*

## **Mathematical Physics - I (Credit - 1; No. of lectures - 15)**

### **Unit I: Vector and scalars (Lectures 2)**

Introduction, dot and cross products including triple products, their physical significance

### **Unit II: Vector differentiation (Lectures 3)**

Ordinary derivative of vectors, continuity, and differentiability, the partial derivative of vectors, applications to problems in Physics.

### **Unit III: Vector differential operator (Lectures 5)**

Gradient, divergence, and curl - definitions and physical meaning, formulas involving  $\nabla$  and invariance

### **Unit IV: Vector Integration (Lectures 5)**

Ordinary integrals of vectors - line integral, surface integral and volume integral, Gauss's theorem, Stoke's theorem and Green's theorem (no rigorous proof is required)

## **Mechanics – I (Credit - 2; No. of lectures - 30)**

### **Unit V: Work energy principle (Lectures 8)**

Laws of motion - Concepts of work, energy, and power, Conservative forces - conservative force as a negative gradient of potential, Conservation of linear and angular momentum, motion of a rocket.

Centre of mass - motion of the centre of mass, collision problem in the centre of mass frame of reference and laboratory frame of reference

### **Unit VI: Rigid body dynamics (Lectures 9)**

Rotational motion - translation and rotational motion, torque, angular momentum. Moment of inertia - general theorem of the moment of inertia, moment of inertia calculation in particular cases - disk, cylinder, and sphere; flywheel, the kinetic energy of rotational motion.

### **Unit VII: Gravitation (Lectures 7)**

Newton's law of gravitation, Gravitational field - the intensity of the field, gravitational potential, and gravitational potential energy; gravitational field and potential due to a solid sphere and spherical shell. Motion under the central force field, two body problems, and reduced mass.

### **Unit VIII: Special theory of relativity (Lectures 6)**

Reference frame - inertial and non-inertial, Galilean Transformation, Galilean Invariance, Postulates of special theory of relativity, Lorentz Transformation equations - length contraction, time dilation and mass variation.

## **PRACTICAL**

**Total Lectures: 30**

*A minimum of five experiments to be done.*

1. To measure the thickness of a piece of glass using a vernier calliper, screw gauge, and spherometer and compare their results.
2. To measure the diameter of a capillary tube using a traveling microscope.
3. To determine the height using a sextant.
4. To determine the Moment of Inertia of a Symmetrical body about an axis by the torsional oscillation method.
5. To determine the moment of inertia of a flywheel.
6. To find the angular acceleration and torque of a flywheel.
7. To determine the value of g using Bar Pendulum.
8. To determine the value of g using Kater's Pendulum
9. To determine the value of g using the motion of an oscillating spring.

### **BOOKS RECOMMENDED:**

1. Vector Analysis, Murray R. Spiegel (Schaum Series)
2. Mathematical Methods for Engineers and Scientists, K. T. Tang
3. Higher Engineering Mathematics, H. K. Das.
4. An Introduction to Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw Hill.
5. Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. Physics, Resnick, Halliday, and Walker 8/e. 2008, Wiley.
8. B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
9. A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

**COURSE NAME: Mathematical Physics - II And Properties Of Matter**

**COURSE CODE: PY- CE - 2114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

### **Course Objectives:**

- *To impart advanced concepts and methods in Mathematics which include the Calculus of vector-valued functions.*
- *To impart basic concepts of work-energy principle, rigid body dynamics, laws of gravitation, and a basic concept of relativity.*

### **Course Learning Outcome:**

**CLO-01:** *After completing the course a student will be able to understand application of differential equation in various fields.*

**CLO-02:** *Further, a student will be able to understand and solve a real-life problem that needs an understanding of elasticity, surface tension and viscosity.*

## **Mathematical Physics - II (Credit - 1, Lectures - 15)**

### **Unit I: Ordinary Differential Equation (Lectures 8)**

Order and degree of a differential equation, 1st order linear differential equation, 1st order and 2nd order homogenous differential equation. Radioactive decay, Newton's law of cooling, Free fall.

### **Unit II: Partial Differential Equation (Lectures 7)**

Solution of Partial differential equation using separation of variables, exact and inexact differentials. Laplace's equation in the cartesian coordinate system, Wave equation.

## **Properties of Matter (Credit - 2, Lectures - 30)**

### **Unit III: Elasticity (Lectures 10)**

Hooke's law, Elastic behaviour of solids, Different types of elasticity, Elastic constants, Relation among different elastic constants, Poisson's ratio, determination of Poisson's ratio, Twisting couple of a cylinder. Bending moment, depression of a cantilever.

### **Unit IV: Surface Tension (Lectures 10)**

Surface tension and surface energy, the Pressure difference across a liquid surface - drops and bubbles, Rise of liquid in a capillary tube - Jurin's law

### **Unit V: Viscosity (Lectures 10)**

The flow of liquid, streamline flow, continuity equation - Bernoulli's theorem and its applications, Viscosity, coefficient of viscosity, Reynold's number, Poiseuille's equation, Effect of temperature and pressure on the viscosity of fluids.

## PRACTICAL

**Total Lectures: 30**

*A minimum of five experiments are to be done.*

1. To determine the Young's Modulus of the material of a wire by Searle's apparatus.
2. To determine the Modulus of Rigidity of a Wire Static method.
3. To determine the spring constant and rigidity modulus from the motion of a spring.
4. To determine the surface tension of water by Jaeger's method.
5. To determine the coefficient of viscosity of water by capillary flow method (Poiseuille's method).
6. To determine the surface tension of a liquid by the capillary rise method and verify Jurin's law
7. To determine the coefficient of viscosity of glycerine or mustard oil by Stoke's method.

### **BOOKS RECOMMENDED:**

1. Mathematical Methods for Engineers and Scientists, K. T. Tang
2. Higher Engineering Mathematics, H. K. Das.
3. An Introduction to Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw Hill.
4. Properties of Matter by D. S. Mathur, S. Chand, and Company.
5. B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
6. A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

**COURSE NAME: Mathematical Physics - III**

**COURSE CODE: PY- CE - 3214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objectives:**

*The objective of the course is to acquaint the learner with different mathematical tools that are necessary for doing any R&D job.*

*It also intended to introduce a few of the numerical recipes like solution of linear and transcendental equations and solving integration by numerical methods which is indispensable component solving problems by computer.*

*Emphasis will be put on explaining the concept with real-life problems.*

**Course Learning Outcome:**

**CLO-01:** *After successful completion of the course, the learner will learn about generalised coordinate system and its transformation to other coordinate system like Cartesian, polar, cylindrical, and spherical polar coordinate system; Matrix algebra, determination of eigen values and eigen vectors, etc.; Randomness of event and theory of probability; The method of error calculation and its minimisation.*

**CLO-02:** *The learner can apply the knowledge of coordinate system and its transformation in different field of science and engineering. The application of matrix is wide not only in Physics but also in different branches of science and technology. The knowledge of matrix will help in understanding and solving problems. The knowledge of error calculation and its minimisation, and also, fitting of experimental data by the method of least square can be applied in different experimental procedure.*

**CLO-03:** *Any real life problem can be analyzed and may be given a matrix representation which is a most common procedure in science and technology. The learner can apply the knowledge of matrix in solving a real life problem. Similar is the case with knowledge of error theory and probability.*

**Unit I - Orthogonal Curvilinear Coordinate (12 lectures)**

Curvilinear coordinates - Unit vectors and scale factors in orthogonal curvilinear coordinates, plane polar coordinates, right circular cylindrical coordinates, and spherical polar coordinates. Arc length, area, and volume elements in each of these systems.

Gradient, Divergence, Curl, and Laplacian in plane polar coordinates, right circular cylindrical coordinates, and spherical polar coordinates.

**Unit II - Matrix algebra (10 lectures)**

Introduction to different types of matrices, Properties of matrices, Transpose of a matrix, complex conjugate matrix, Hermitian matrix, special square matrix, unit matrix, diagonal matrix, co-factor matrix, adjoint of a matrix, self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix.

Eigenvalue problems, Cayley-Hamilton Theorem, Diagonalization of matrices.

### **Unit III - Dirac Delta Function (7 lectures)**

Definition of Dirac delta function. Representation as the limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

### **Unit IV - Some Special Integrals (8 lectures)**

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

### **Unit V - Theory of Probability and Errors (8 lectures)**

Independent random variables, Probability distribution functions of Binomial, Gaussian, and Poisson, with examples. Mean and variance.

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least- squares fit.

## **PRACTICAL**

### **Total Lectures: 30**

#### **Basics of Coding**

- Basics of Scientific Computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, numerical errors of elementary floating point operations, round off and truncation errors with examples.

Introduction to Algorithms and Flow charts. Branching with examples of conditional statements, for and while loops.

- Basic Elements of Python: Variables and assignments, variable types, output and input statements, arithmetic operations, comment statement.

- Control Statements: Logical statements- IF, IF-ELSE block, Looping Statements- WHILE, FOR loop, indentation, break and continue, List comprehension.

- Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules.

- Basics of Numpy: Importing Numpy, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using ones(), zeros(), random(), arange(), linspace(). Basic array operations (sum, max, min, mean, variance), 2-d and 3-d arrays, matrix operations, reshaping and transposing arrays, random number generation using rand().

- Basics of Matplotlib: Introduction to graphical analysis, the importance of visualization of computational data, matplotlib.pyplot functions, simple plots.

#### **List of Programs**

1. To find a set of prime numbers between two given numbers.
2. To find the Fibonacci series up to 10 terms.
3. Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
4. To transform a point from cartesian coordinate system to polar coordinate system and vice-versa.

5. Generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.
6. Generate random numbers and calculate area of circle, area of square, volume of sphere, value of  $\pi$ .

### **Matrix Algebra**

Write a suitable code

1. To create a matrix with or without using numpy array/matrix.
2. To add, multiply two matrices.
3. To find determinant and inverse of a matrix.
4. To find eigen values and eigen vectors of a matrix.

### **Method of Least square Fitting of experimental data:**

Write a suitable code to fit experimental data by the method of least squares, test goodness of fit, and standard deviation of

1. Voltage-Current data from Ohm's law experiment and hence to find the value of resistance.
2. Load-Elongation data taken from Young's law experiment and calculating the value of Young's modulus (Y ) from the fitted data.

### **BOOKS RECOMMENDED:**

1. Murray R Spiegel. Schaum's Outline of Theory and Problems of Vector Analysis. Schaum, 1959.
2. Richard Bronson. Theory and problems of matrix operations. The McGraw Hill Companies, 1989.
3. K.T. Tang. Mathematical Methods for Engineers and Scientists 1: Complex Analysis, Determinants and Matrices. Mathematical Methods for Engineers and Scientists. Springer Berlin Heidelberg, 2006. ISBN: 9783540302742.  
URL: <https://books.google.co.in/books?id=orOTiguKIR4C>.
4. HK Dass. Higher Engineering Mathematics. S. Chand Publishing, 2011.
5. John Robert Taylor and William Thompson. An introduction to error analysis: the study of uncertainties in physical measurements. Vol. 2. Springer, 1982.
6. Shankar S Sastry. Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.
7. S.R.K. Iyengar and R.K. Jain. Numerical Methods (As Per Anna University). New Age International (P) Limited, 2009. ISBN: 9788122426106.  
URL: <https://books.google.co.in/books?id=5p5jFxb16UEC>.
8. D. Walker. Computational Physics: An Undergraduate's Guide. Pantaneto introductory physics series. Pantaneto Press, 2013. ISBN: 9780992636807.  
URL: <https://books.google.co.in/books?id=KTzooAEACAAJ>.
9. T. Pang. An Introduction to Computational Physics. Cambridge University Press, 2006. ISBN: 9780521825696. URL: <https://books.google.co.in/books?id=zTO-jzbfD3wC>.
10. M.E.J. Newman. Computational Physics. CreateSpace Independent Publishing Platform, 2013. ISBN: 9781480145511.

URL: <https://books.google.co.in/books?id=SS6uNAEACAAJ>.

11. Robert Johansson, Robert Johansson, and Suresh John. Numerical python. Vol. 1. Springer, 2019.
12. Jaan Kiusalaas. Numerical methods in engineering with Python 3. Cambridge university press, 2013.

**COURSE NAME: Optics**

**COURSE CODE: PY- CE - 3224**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

### **Course Objective**

- *To impart knowledge regarding image formation due to a system of lenses.*
- *To impart knowledge about the matrix method of studying paraxial optics.*
- *To impart knowledge about wave like behaviour of light and related phenomena like interference, diffraction, and polarization.*

### **Course Learning Outcome**

**CLO–01:** *After successful completion of the course, a learner will learn about formation of image due to a system of lenses, different types of magnifications, defects of images of different types, and matrix method of studying geometrical optics.*

**CLO–02:** *Also, the learner will learn about detailed theory of wave like behaviour of light through the phenomena - interference, diffraction, and polarisation as well as associated phenomena - colour of thin film, Newton's ring etc.*

**CLO–03:** *Biprism experiment, Newton's ring experiment, Michelson Interferometer, Grating experiment, experiment with polarimeter will give better insight into the subject.*

### **Unit I - Ray Optics (20 lectures)**

Fermat's principle - its application to laws of reflection and refraction, Refraction of paraxial rays at a single spherical surface, thick lens, magnification of image, interrelation among lateral, longitudinal, and angular magnification, Lagrange's law, and Helmholtz equation.

Defects of image

Spherical aberration and its minimization, Qualitative idea about coma, astigmatism and distortion, Chromatic aberration.

Matrix method of paraxial optics

Translation matrix and Refraction Matrix, use of matrix method in refraction at a spherical surface and refraction through thin lens, zone matrix.

### **Unit II - Wave Optics (25 lectures)**

Interference

Concept of light wave and its equation, Stokes' law, interference due to Fresnel's biprism, interference by a plane parallel film, colour of thin film, Newton's rings, Michelson interferometer and its application for finding difference in wavelengths.

Diffraction

Difference between Fresnel and Fraunhofer classes, half-period zones and strips, Zone plate and its lensing property, diffraction at a straight edge and a circular aperture, Fraunhofer diffraction due to a single slit,

grating (its reduction to double slit), Resolving power and Dispersive power (derivation not required).

### Polarisation

Plane polarised light, polarisation on reflection, Brewster's law, double refraction, Nicol prism, rotation of plane of polarization by optically active substances, specific rotation, polarimeter.

## PRACTICAL

**Total Lectures: 30**

### List of Experiments

*Minimum experiments to be performed is seven*

1. To determine the refractive index of a liquid by using plane mirror and convex lens.
2. To determine the focal length of two lenses and their combination by displacement method.
3. Familiarization with Schuster's focusing, determination of angle of prism.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine wavelength of sodium light using Newton's Rings.
8. To determine the thickness of a thin sheet/paper by measuring the width of the interference fringes produced by a wedge- shaped Film.
9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10. To determine dispersive power and resolving power of a plane diffraction grating.
11. To verify the law of Malus for plane polarized light.
12. To determine the specific rotation of sugar solution using Polarimeter.
13. To analyze elliptically polarized Light by using a Babinet's compensator.
14. To find the difference in wavelength using Michelson Interferometer.

### BOOKS RECOMMENDED:

1. B Ghosh and KG Mazumdar. "A Text Book on Light". In: Sreedhar Pub., Calcutta, (2003).
2. P Chakrabarti. Geometrical & Physical Optics. New Central Book Agency, 2010.
3. A. Ghatak. Optics. McGraw-Hill Education, 2009. ISBN: 9780073380483.  
URL: <https://books.google.co.in/books?id=KTMHOQAACAAJ>.
4. Eugene Hecht. Optics. Pearson Education India, 2012.
5. CL Arora. B. Sc. Practical Physics. S. Chand Publishing, 2001.
6. S.K. Ghosh. A Textbook of Practical Physics. New Central Book Agency (P) Limited, 2008. ISBN: 9788173811609.  
URL: <https://books.google.co.in/books?id=L3ElrgEACAAJ>.
7. D Chattopadhyay and PC Rakshit. An advanced course in practical physics. New Central Book Agency, 1990.

**COURSE NAME: Mathematical Physics - IV**

**COURSE CODE: PY- CE - 4214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objective:**

*The objective of the course is to acquaint the learner with the method of solving differential equation by series method (Frobenius method), and also to introduce with other types of differential equations - Legendre, Hermite and their properties. They also learn Dirac Delta Function, some special integrals - Beta and Gamma functions, Tensor analysis.*

**Course Learning Outcome**

- CLO – 01:** *After successful completion of the course, a learner will receive broad overview of solving differential equation by series method. Similarly, they will be acquainted with other mathematical tools like Dirac-Delta function, Beta-Gamma function and Tensor analysis.*
- CLO – 02:** *These mathematical tools have extensive applications in the field of Quantum Mechanics, General Theory of Relativity and many more.*
- CLO – 03:** *So, these knowledge will help a learner in solving problems related to Quantum Mechanics, General Theory of Relativity, etc.*

**Unit I - Series solution of differential equation (15 lectures)**

Second order linear differential equations, series method of solutions (Frobenius), Legendre's differential equations, Legendre's polynomial, Hermite's differential equations, Hermite's polynomial, generating function, spherical harmonics, orthogonal properties & recurrence relations.

**Unit II - Fourier Series (6 lectures)**

Periodic functions. Orthogonality of sine and cosine functions, Convergence of Fourier series and Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions (Fourier Cosine Series and Fourier Sine Series).

**Unit III - Tensor Analysis (8 lectures)**

Introduction to tensor - Transformation of coordinates, Einstein's summation convention. contravariant and covariant tensor, tensorial character of physical quantities, symmetric and antisymmetric tensors, Kronecker delta, Levi-Civita Tensor.

Rules for combination of tensors - addition, subtraction, outer multiplication, contraction, and inner multiplications. Quotient law of tensors

**Unit IV - Solution of Linear and Non-linear Equations (10 lectures)**

Simultaneous linear equations - Gauss elimination method, Gauss-Siedel method. Non-linear equations - Bisection method, Newton-Raphson method, Sectant method.

## Unit V - Numerical Integration

(6 lectures)

Numerical integration - trapezoidal rule, Simpson's 1/3 rd rule.

### PRACTICAL

#### Total Lectures: 30

Solution of linear and non-linear equations

Using Bisection, Newton Raphson and Secant methods, find out roots of the equation.

1. To approximate nth root of a number up to a given number of significant digits.
2. Solve transcendental equations (a)  $\alpha = \tan \alpha$ , (b)  $\sin \alpha = \sqrt{m}\alpha$ .
3. Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of given density.

Use Gauss elimination method, Iterative methods like Gauss Seidel method for solving system of linear equations.

1. Use Kirchhoff's laws to write down the set of mesh equations for a given linear electric circuit and solve the mesh equations (3 meshes).
2. Solve coupled spring mass system (3 masses).

#### Numerical Integration

Use Trapezoidal rule, Simpson's 1/3 rd Rule, to evaluate the following integration.

1. Given positions with equidistant time interval, find the velocity and acceleration of a particle in motion.
2. Evaluate:

$$\frac{1}{\sqrt{2\pi\sigma^2}} \int \exp\left(-\frac{(x-2)^2}{2\sigma^2}\right) (x+3) dx$$

for  $\sigma = 1, 0.1, 0.001$  and show that it tends to 5.

3. Evaluate:

$$\int_{-\infty}^{\infty} \frac{dx}{1+x^2}$$

4. Evaluate the Fourier coefficients of a given periodic functions (a) square wave, and (b) saw tooth wave and represent them graphically.
5. Verify the properties of Dirac Delta function using its representation as a sequence of functions - Gaussian functions and rectangular functions.
6. Plot (a) Legendre's polynomial, (b) Bessel's function.
7. Verify the Orthogonality of Legendre Polynomials.

### BOOKS RECOMMENDED

1. K.T. Tang. Mathematical Methods for Engineers and Scientists 2: Vector Analysis, Ordinary Differential Equations and Laplace Transforms. Mathematical Methods for Engineers and Scientists. Springer Berlin Heidelberg, 2006. ISBN: 9783540302704. URL: <https://books.google.co.in/books?id=r0zrNgOLurIC>.
2. M.R. Spiegel. Schaum's Outline of Fourier Analysis with Applications to Boundary Value

- Problems. Schaum's Outline Series. McGraw Hill LLC, 1974. ISBN: 9780071783637. URL: <https://books.google.co.in/books?id=WoK9OEOynSUC>.
3. H K Dass. Higher Engineering Mathematics. S. Chand Publishing, 2011.
  4. Shankar S Sastry. Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.
  5. S.R.K. Iyengar and R.K. Jain. Numerical Methods (As Per Anna University). New Age International (P) Limited, 2009. ISBN: 9788122426106. URL: <https://books.google.co.in/books?id=5p5jFxb16UEC>.
  6. D. Walker. Computational Physics: An Undergraduate's Guide. Pantaneto introductory physics series. Pantaneto Press, 2013. ISBN: 9780992636807. URL: <https://books.google.co.in/books?id=KTzooAEACAAJ>.
  7. T. Pang. An Introduction to Computational Physics. Cambridge University Press, 2006. ISBN: 9780521825696. URL: <https://books.google.co.in/books?id=zTO-jzbfD3wC>.
  8. M.E.J. Newman. Computational Physics. CreateSpace Independent Publishing Platform, 2013. ISBN: 9781480145511. URL: <https://books.google.co.in/books?id=SS6uNAEACAAJ>.
  9. Robert Johansson, Robert Johansson, and Suresh John. Numerical python. Vol. 1. Springer, 2019.
  10. Jaan Kiusalaas. Numerical methods in engineering with Python 3. Cambridge university press, 2013.

## **COURSE NAME: Waves & Applied Optics**

**COURSE CODE: PY- CE - 4224**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to acquaint the learner with the concept of oscillatory motion of simple harmonic type and its different characteristics. Also, a broad overview will be given about propagation of wave in an elastic medium and different aspects of sound wave. Also, Fourier analysis of sound wave will be done. Principles of Laser, Holography, and Fibre Optics will be discussed along with their applications.*

Course Learning Outcome:

**CLO – 01:** *This course will acquaint the learner with the oscillatory motion of simple harmonic type and its classification under different physical conditions; phenomenon like resonance. They will learn about wave motion in an elastic medium and its mathematical analysis, superposition of waves, stationary waves.*

**CLO – 02:** *Also, they will learn about propagation of sound in an elastic medium, Newton's formula to determine the velocity of sound and Laplace correction. Fourier analysis of sound wave will also be learned in this course.*

**CLO – 03:** *This course will help in understanding musical notes and working of the musical instruments; necessary criteria for constructing an auditorium etc.*

**CLO – 04:** *After the course, the student will learn to handle practical instruments with laser, learn holography and fibre optics.*

#### **Unit I - Harmonic Motion (8 lectures)**

Simple Harmonic motion, Composition of two simple harmonic oscillations at right angles, Lissajous figures. Free, damped, and forced oscillations, resonance, and sharpness of resonance.

#### **Unit II - Wave Motion (6 lectures)**

Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of Wave Equation. Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave, Water Waves - Ripple and Gravity Waves.

#### **Unit III - Sound Wave (8 lectures)**

Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal Waves in a Fluid in a Pipe, Newton's Formula for Velocity of Sound, Laplace's Correction, Effect of temperature and pressure on velocity of sound in air, intensity level of sound and its unit (bel and decibel), Acoustics of auditorium, reverberation, Sabine's law.

#### **Unit IV - Superposition of Two Harmonic Waves (8 lectures)**

Standing (Stationary) Waves in a String - Fixed and Free Ends, Phase and Group Velocities, Changes w.r.t Position and Time. Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings, Plucked and Struck Strings, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes.

## Unit V - Applied Optics

(15 lectures)

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

**Holography** - Basic principle and theory, coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition.

**Fibre Optics** - Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Basic ideas about optical fibre communication system.

## PRACTICAL

### Total Lectures: 30

*Minimum experiments to be performed is six.*

1. Study the motion of a spring in different medium (a) air and (b) water/kerosene oil. Calculate the value of  $g$  in both cases and compare the result.
2. Determine the frequency of an electric tuning fork by Melde's experiment and verify the  $\lambda^2 - T$  law.
3. Study the Lissajous figure of two waves using a CRO and determine the value of unknown frequency of the wave.
4. Determine the velocity of sound wave in air at room temperature using a resonance tube at three different resonance positions.
5. Study the relation between frequency and length/tension of a given wire under constant tension using a sonometer and also plot a graph between frequency and length/tension.
6. Study the diffraction of light due to the propagation of an ultrasonic wave in a given liquid and calculate the speed of sound in the given liquid.
7. Determine the grating radial spacing of the CD and DVD by using either reflection or refraction method with a He-Ne or Solid State laser. Compare the experimental values with the theoretical one.
8. Find the width of the given wire using diffraction pattern obtained by a He-Ne or solid state laser and verify the result using a screw gauge.
9. Study the V-I characteristics of a light dependent resistor (LDR). Show the relation between resistance and distance of light source and calculate the dark resistance of the LDR.
10. Study the V-I characteristics of a photovoltaic cell and calculate the fill factor and efficiency of the cell.
11. Measure the numerical aperture and acceptance angle of an optical fibre.

### BOOKS RECOMMENDED:

1. N.K. Bajaj. The physics of waves and oscillations. Tata McGraw-Hill, 1988. ISBN: 9780074516102. URL: <https://books.google.co.in/books?id=1w1HzwEACAAJ>.
2. M.G.D. Bhattacharya. A Textbook Of Oscillations, Waves And Acoustics, 5th Edition. S

- Chand & Company Lim-Ited, 2016. ISBN: 9789385676154.  
URL: <https://Books.Google.Co.In/Books?Id=Maordaaaqbaj>.
3. H.J. Pain. Physics of Vibrations and Waves. John Wiley & Sons, Incorporated., 2005.  
URL: <https://books.google.co.in/books?id=2zBN0AEACAAJ>.
  4. Anthony Philip French. Vibrations and waves. CRC press, 2017.
  5. Francis A. Jenkins and Harvey E. White. Fundamentals of Optics. Tata McGraw-hill, 1981.
  6. K.Thyagarajan and A.K.Ghatak. LASERS: Fundamentals & applications. Tata McGraw Hill, 2010.
  7. M.R. Shenoy et al. Fiber Optics Through Experiments. MV Learning, 2015. ISBN: 9788130929835. URL: [https://books.google.co.in/books?id=Z\\_VzjwEACAAJ](https://books.google.co.in/books?id=Z_VzjwEACAAJ).
  8. S.C. Gupta. Optoelectronic Devices And Systems. PHI Learning, 2014. ISBN: 9788120350656.  
URL: <https://books.google.co.in/books?id=zmfkBQAAQBAJ>.
  9. A. Lipson, S.G. Lipson, and H. Lipson. Optical Physics. Cambridge University Press, 2010. ISBN: 9781139492607. URL:<https://books.google.co.in/books?id=aow3o0dhyjYC>

**COURSE NAME: Electricity And Magnetism**

**COURSE CODE: PY- CE - 4234**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to give the learners a broad overview of Electrostatics, Current Electricity and Magnetostatics which are essentially required for the pursuance of Higher Studies or doing R & D job.*

Course Learning Outcome:

**CLO – 01:** *One will learn the fundamental properties of charged particles and electric fields in this course.*

**CLO – 02:** *This course will give learners an understanding of the phenomena of electricity, magnetism, electromagnetic induction, and electrical circuits which are essential for higher studies in physics and also important for various engineering applications.*

**CLO – 03:** *This course builds the basis for studying more advanced topics in electromagnetic theory*

**Unit I – Electrostatics (15 lectures)**

Electric field, Divergence of Electric field, Gauss's law of electric field in integral and differential form, Applications of Gauss's law for linear, surface and volume charge distribution. Curl of an electric field, Electric potential, electric potential due to a uniformly charged - (a) wire, (b) ring, and (c) disc. Electric dipole, Potential and field due to a dipole, dipole in a uniform external electric field, dipole-dipole interaction. Multipole expansion of electrostatic potential due to a volume distribution of charge.

**Electrostatic boundary conditions**

Electrostatic energy: Energy of (a) an assembly of point charges, (b) a uniformly charged sphere. Laplace's and Poisson's equations, boundary conditions and Uniqueness theorem, Solutions of Laplace's equation in one dimension: Electric potential and intensity (a) inside an infinite parallel plate capacitor, (b) inside spherical capacitor, and (c) due to a long and uniformly charged conducting wire.

**Method of electrical image**

Method of electrical image with examples of (a) infinite grounded conducting plane and (b) grounded conducting sphere.

**Unit II - Current Electricity (15 lectures)**

Electric current density, continuity equation, Ohm's law, Applications of Kirchhoff's law to solve electrical network problem, Kelvin double bridge for low resistance measurement, moving coil ballistic galvanometer and its sensitivity.

Self and mutual induction, coefficient of coupling, reciprocity theorem, self induction of a long solenoid, mutual induction of two solenoids, measurement of L and M using d.c. source and ballistic galvanometer.

Transient growth and decay of current in LR, CR and LCR circuits, oscillatory discharge. Thermo electricity: Coefficients of thermo-emf, thermoelectric power, basic ideas of Seebeck and Peltier effects.

Generation of alternating current, Phasor (complex number method) method of analyzing a.c. circuits, current and potential across resistive, inductive and capacitive elements and their phase relationships, power factor, LR, CR and LCR(series and parallel) circuits, quality factor, resonance; Maxwell's LC bridge and Anderson's bridge.

Rotating magnetic field, a.c. motor, transformer, reflected impedance in transformer, use of transformer.

### **Unit III – Magnetostatics (15 lectures)**

Magnetic field, Lorentz force, Cyclotron motion, cycloid motion, Biot-Savart law, Magnetic field due to a steady current in (a) straight conductor and (b) a circular coil. Divergence and Curl of a magnetic field. Ampere's circuital law: magnetic field due to a (a) long straight conductor and (b) an infinite solenoid carrying a steady current, Magnetic scalar and vector potential. Force and torque on a current loop in a uniform magnetic field, Current loop as a magnetic dipole.

## **PRACTICAL**

### **Total Lectures: 30**

#### List of Experiments

*Minimum experiments to be performed is five*

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

### **BOOKS RECOMMENDED:**

1. D.J. Griffiths. Introduction to Electrodynamics. Cambridge University Press, 2017. ISBN: 9781108357142. URL: <https://books.google.co.in/books?id=Kh4xDwAAQBAJ>.
2. Vasudeva. D. N. Fundamentals of Magnetism and Electricity. S. Chand Limited, 2007. ISBN:

9788121909556. URL: <https://books.google.co.in/books?id=DbucEAAAQBAJ>.
3. D. Chattopadhyay. Electricity And Magnetism. New Central Book Agency (P) Limited, 2013. ISBN: 9788173812514. URL: <https://books.google.co.in/books?id=0WWmcgeF1XQC>.
4. Laud. B. B. Electromagnetics. Wiley Eastern, 1987. ISBN: 9780852264997. URL: <https://books.google.co.in/books?id=XtgFvbd9F2UC>.
5. K K Tewari. Electricity and Magnetism. S. Chand Limited, 1995. ISBN: 9788121906678. URL: <https://books.google.co.in/books?id=wQsrDAAAQBAJ>.

**COURSE NAME: Mathematical Physics - V**

**COURSE CODE: PY- CE - 5314**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to acquaint the learner with Complex Analysis and Complex Integration, Fourier and Laplace Transformation.*

Course Learning Outcome:

**CLO – 01 :** *After successful completion of the course, the learner will learn about Complex analysis and Complex Integration. They will also learn Fourier and Laplace transformation.*

**CLO – 02:** *These mathematical tools will help the learner to study various branches of science and engineering. This knowledge will help them in future study as well.*

### **Unit I - Complex Analysis (15 lectures)**

Brief Revision of Complex Numbers and their Graphical Representation, Euler's formula, De Moivre's theorem, Roots of Complex Numbers

Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions - poles and branch points, order of singularity, branch cuts.

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

### **Unit II - Fourier Transform (10 lectures)**

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian functions Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem (Statement only). Properties of Fourier transform (translation, change of scale, complex conjugation).

### **Unit III - Laplace Transform (8 lectures)**

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem (Statement only). Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator.

### **Unit IV - Numerical Solution of Ordinary Differential Equation and Partial Differential Equation (12 lectures)**

Euler's method, Modified Euler's method, Runge-Kutta method of order 2 and 4, finite difference method to solve PDE.

## PRACTICAL

### Total Lectures: 30

#### List of Experiments

### Numerical Solution of Ordinary Differential Equation

**First order ODE** - Solution of 1st order ODE by Euler's method, Modified Euler method, Runge-Kutta method of order 2.

1. Classical equation of motion.
2. Radioactive decay.
3. Newton's law of cooling.
4. Current in RC, LC circuits with DC source.

**Second order ODE** - solving by Euler's method, modified Euler's method, RK2 method, and Finite difference method.

1. The motion of a simple harmonic oscillator without considering the effect of damping.
2. The motion of damped harmonic oscillator highlighting (a) overdamped, (b) critically damped, and (c) underdamped conditions.

### Boundary value problem -

1. Solve  $y''(x) + y(x) = 0$  with  $y(0) = 1$ ,  $y(\pi/2) = 1$  for  $0 < x < \pi$ .
2. Motion of a projectile in a resistive medium.

### Numerical Solution of Partial Differential Equation-

The solution of partial differential equation numerically by finite difference method.

1. Solve heat equation, and
2. Solve the equation of sound wave.

### Complex Analysis, Fourier Transformation, and Laplace Transformation-

1. Find the two square roots of  $5 + 12j$ .
2. Evaluate Fast Fourier Transformation (FFT) of  $e^{x^2}$ .
3. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.

### BOOKS RECOMMENDED:

1. M.R. Spiegel et al. *Schaum's Outline of Complex Variables, 2ed.* Schaum's Outline Series. McGraw Hill LLC, 2009. ISBN: 9780071615709.  
URL: <https://books.google.co.in/books?id=EjT3fE2SgGwC>.
2. K.T. Tang. *Mathematical Methods for Engineers and Scientists 1: Complex Analysis, Determinants and Matrices.* Mathematical Methods for Engineers and Scientists. Springer Berlin Heidelberg, 2006. ISBN: 9783540302742.  
URL: <https://books.google.co.in/books?id=orOTiguKIR4C>.
3. HK Dass. *Higher Engineering Mathematics.* S. Chand Publishing, 2011.

4. Shankar S Sastry. Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.
5. S.R.K. Iyengar and R.K. Jain. Numerical Methods (As Per Anna University). New Age International (P) Limited, 2009. ISBN: 9788122426106. URL: <https://books.google.co.in/books?id=5p5jFxb16UEC>.
6. D. Walker. Computational Physics: An Undergraduate's Guide. Pantane to introductory physics series. Pantane to Press, 2013. ISBN: 9780992636807. URL: <https://books.google.co.in/books?id=KTzooAEACAAJ>.
7. T. Pang. An Introduction to Computational Physics. Cambridge University Press, 2006. ISBN: 9780521825696. URL: <https://books.google.co.in/books?id=zTO-jzbfD3wC>.
8. R.H. Landau, M.J. Páez, and C.C. Bordeianu. Computational Physics: Problem Solving with Python. EBL-Schweitzer. Wiley, 2015. ISBN: 9783527413157.  
URL: <https://books.google.co.in/books?id=gR6zCQAAQBAJ>.
9. M.E.J. Newman. Computational Physics. Create Space Independent Publishing Platform, 2013. ISBN: 9781480145511. URL: <https://books.google.co.in/books?id=SS6uNAEACAAJ>.
10. Robert Johansson, Robert Johansson, and Suresh John. Numerical python. Vol. 1. Springer, 2019.
11. Jaan Kiusalaas. Numerical methods in engineering with Python 3. Cambridge university press, 2013

## **COURSE NAME: Classical Mechanics**

**COURSE CODE: PY- CE - 5324**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective :

*Here, the objective is to provide the learner a broad overview of mechanics of a point particle. Apart from Newtonian approach, Lagrangian and Hamiltonian approach is introduced to study a dynamical system with reference to practical examples. Also broad overview of relativistic mechanics will be provided.*

Course Learning Outcome :

**CLO – 01:** *After successful completion of the course, the learner will Understand the fundamental concepts of analytical mechanics such as generalized coordinates and velocity, the Lagrange and Hamilton functions.*

**CLO – 02:** *The learners will develop the ability to use the Lagrange and Hamilton equations to solve complex mechanical problems.*

**CLO – 03:** *Knowledge of relativistic mechanics will help learning advanced topics in Quantum Mechanics, Nuclear Physics, General Theory of Relativity, etc.*

### **Unit I - Classical Mechanics (30 lectures)**

#### **D'Alembert's Principle and Lagrangian Equation**

Co-ordinate system, constraints, Generalized co-ordinate and velocity, generalized force, principle of virtual work, D'Alembert's principle, Lagrange's equation of motion. Applications - one dimensional simple harmonic oscillator, freely falling body under gravity, coupled oscillators.

#### **Hamiltonian Dynamics and Poisson Bracket**

Legendre Transformation, Hamilton's Canonical Equation of Motion, Hamiltonian Applications - one dimensional simple harmonic oscillator, particle in a central force field- conservation of angular momentum and energy, planetary motion - Kepler's problem.

#### **Motion under Central Force and theory of scattering**

Central force motion, two body central force motion, Equation of the orbit under central force, Planetary motion - Kepler's laws. Scattering of a particle by a hard sphere, Center of mass and Laboratory System of Scattering - Rutherford Scattering.

#### **Fluid Motion**

Concept of viscosity and terminal velocity, Continuity equation and mass conservation, stream line and laminar motion, Reynold's number, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation,

## **Unit - II Relativistic Mechanics (15 lectures)**

Relativistic momentum and energy, Equivalence of mass and energy. Massless particles (i.e. photons). The geometry of spacetime and space-time interval. Four-vectors: spacelike, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

### **BOOKS RECOMMENDED:**

1. H. Goldstein, C.P. Poole, and J.L. Safko. Classical Mechanics. Addison Wesley, 2002. ISBN: 9780201657029. URL: <https://books.google.co.in/books?id=tJCuQgAACAAJ>.
2. R.G. Takwale and P.S. Puranik. Introduction to Classical Mechanics. Tata McGraw-Hill, 1980. URL: <https://books.google.co.in/books?id=wDQWyAEACAAJ>.
3. K.C. Gupta. Classical Mechanics of Particles and Rigid Bodies. Wiley, 1988. ISBN: 9788122400045. URL: <https://books.google.co.in/books?id=bK7vAAAAMAAJ>.
4. N.C. Rana and J.P. Sharadchandra. Classical Mechanics. Tata Mac Graw Hill, 1991. URL: <https://books.google.co.in/books?id=67NWPgAACAAJ>.
5. S.N. Biswas. Classical Mechanics. Books & Allied Limited, 2014. ISBN: 9788187134183. URL: [https://books.google.co.in/books?id=Y0H\\_zgEACAAJ](https://books.google.co.in/books?id=Y0H_zgEACAAJ).
6. L.D. Landau and E.M. Lifshitz. Mechanics: Volume 1. v. 1. Elsevier Science, 1982. ISBN: 9780080503479. URL: <https://books.google.co.in/books?id=bE-9tUH2J2wC>

## **COURSE NAME: Thermal Physics**

**COURSE CODE: PY- CE - 5334**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to provide a broad overview of thermodynamics covering the fundamental principles involved - First and Second law of thermodynamics, conversion of heat into work and vice-versa, Carnot engine, concept of entropy, importance of thermodynamic potentials etc.*

*Also, the kinetic theory of gases will be covered with an objective to learn the molecular motion of gaseous particles, phenomena like thermal conduction, diffusion, brownian motion, etc.*

Course Learning Outcome

**CLO – 01:** *After successful completion of the course, the learner will Understand the basic laws of nature associated with heat and thermodynamics, the conversion of heat into work and vice-versa, principle of working of machine - carnot engine, concept of entropy, thermodynamic potentials, etc. Also, they will learn about kinetic theory of gases.*

**CLO – 02:** *They will learn to apply the concept of kinetic theory of gases to explain the real life physical phenomena like thermal conductivity, diffusion of gases in a medium, phenomenon like brownian motion, etc.*

### **Unit I - Introduction to Thermodynamics (30 lectures)**

#### **Zeroth and First Law of Thermodynamics:**

Zeroth Law of Thermodynamics & Concept of Temperature, First Law of Thermodynamics and its differential form, Internal Energy, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient.

#### **Second Law of Thermodynamics**

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

#### **Entropy**

Concept of Entropy, Clausius Theorem, Second Law of Thermodynamics, Entropy of a perfect gas, Entropy Changes in Reversible and Irreversible processes, Principle of Increase of Entropy. Temperature-Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

#### **Thermodynamic Potentials**

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

## Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of  $C_P - C_V$ , (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

## Unit II - Kinetic Theory of Gases (15 lectures)

### Distribution of Velocities

Pressure exerted by a gas using spherical polar coordinates, Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification, Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

### Molecular Collisions

Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

## PRACTICAL

### Total Lectures: 30

List of Experiments

*Minimum number of experiments to be performed is four.*

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To determine the boiling point of a given liquid with the help of Platinum Resistance Thermometer (PRT).
7. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.
8. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

## BOOKS RECOMMENDED:

1. P.K. Chakrabarti. Theory and Experiments on Thermal Physics. New Central Book Agency (P) Limited, 2013. ISBN: 9788173815041. URL: <https://books.google.co.in/books?id=JCNXhdvWCGkC>.
2. J.P. Agarwal and S. Prakash. Thermodynamics and Statistical Physics. Pragati Prakashan, 1993. URL: <https://books.google.co.in/books?id=6UCcGwAACAAJ>.
3. S.C. Garg, R.M. Bansal, and C.K. Ghosh. Thermal Physics: Kinetic Theory,

Thermodynamics and Statistical Me-chanics. McGraw Hill Education (India) Private Limited, 2013. ISBN: 9781259097614.

URL: <https://books.google.co.in/books?id=VAbvjgEACAAJ>.

4. F.W. Sears and G.L. Salinger. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics. Addison-Wesley principles of physics series. Addison-Wesley Publishing Company, 1975. ISBN: 9780201068948.

URL: <https://books.google.co.in/books?id=3gRRAAAAMAAJ>

## **COURSE NAME: Analog Electronics**

**COURSE CODE: PY- CE - 5344**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective:

*This course will give foundation of the semiconductor electronics so that one can work in any industry or pursue higher studies or do R&D job in future.*

Course Learning Outcome :

**CLO – 01:** *This course forms the basis of electronics which is responsible for the technological advances of the present-day world.*

**CLO – 02:** *The learner will understand the basic concepts of semiconductor physics and its application.*

**CLO – 03:** *They will learn about the operation, characteristics, and various applications of different types of diodes, transistors, field effect transistors, OPAMP, and oscillators.*

**CLO – 04 :** *They will also have an idea about the working of amplifier and regulated power supply.*

#### **Unit I - Semiconductor Diodes (8 lectures)**

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current flow mechanism in Forward and Reverse Biased Diode. Static and Dynamic Resistance.

#### **Unit II - Two-terminal Devices and their Applications (6 lectures)**

(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LED, (2) Photodiode, (3) Solar Cell, (4) Tunnel diode, and (5) Schottky diode (no derivation).

#### **Unit III - Network theorem (3 lectures)**

Thevenin, Norton, Superposition, Reciprocity theorem and maximum power transfer theorem.

#### **Unit IV - Bipolar Junction Transistors (6 lectures)**

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains  $\alpha$  and  $\beta$ . Relations between  $\alpha$  and  $\beta$ . Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

#### **Unit V – Amplifiers (9 lectures)**

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Two stage D-coupled amplifier and its frequency response. Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

## Unit VI - Sinusoidal Oscillators (4 lectures)

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

## Unit VII - Operational Amplifiers (Black Box approach) (5 lectures)

Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

(1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

## Unit - VIII Cathode Ray Oscilloscope (4 lectures)

Block diagram of CRO, various components of cathode ray tube, deflection sensitivity, generation of wave form, measurement of voltage, current, frequency, phase difference using CRO, basic idea of DSO (digital Storage Oscilloscope).

## PRACTICAL

### Total Lectures: 30

#### List of Experiments

***Minimum number of experiments to be performed is twelve.***

1. To study V-I characteristics of PN junction diode both in forward and reverse bias conditions.
2. To study V-I characteristics of Light emitting diode in forward bias for two different colours.
3. To study the V-I characteristics of a Zener diode in reverse biased condition and its use as voltage regulator.
4. To study of V-I and power curves of solar cells, and find maximum power point and efficiency.
5. To verify Thevenin's and Norton's theorems.
6. To verify the superposition and maximum power transfer theorem.
7. To find the value of ripple factor and efficiency of a full wave rectifier.
8. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
9. To study the various biasing configurations of BJT for normal class A operation.
10. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
11. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
12. To design a Wien bridge oscillator for given frequency using an op-amp.
13. To design a phase shift oscillator of given specifications using BJT.
14. To study the Colpitt's oscillator.
15. To design a digital to analog converter (DAC) of given specifications.
16. To study the analog to digital convertor (ADC) IC.
17. To design an inverting amplifier using Op-amp (741/351) for dc voltage of given gain .
18. To design inverting amplifier using Op-amp (741/351) and study its frequency response.
19. To design non-inverting amplifier using Op-amp (741/351) and study its frequency response.

20. To study the zero-crossing detector and comparator.
21. To add two dc voltages using Op-amp in inverting and non-inverting mode.
22. To design a precision Differential amplifier of given I/O specification using Op-amp.
23. To investigate the use of an op-amp as an Integrator.
24. To investigate the use of an op-amp as a Differentiator.
25. To measure voltage and frequency of a periodic waveform using CRO.
26. To construct a series LR circuit. Display the two waveforms on the CRO and measure the phase differences between the voltages across L and R.

#### **Recommended Books:**

1. J. Millman. Integrated Electronics: Analog And Digital Circuits And Systems. Mcgraw-Hill Education (India) Pvt Limited, 2010. Isbn: 9780070151420. Url: <https://books.google.co.in/books?id=R4x9zgeacaaj>.
2. J.D. Ryder. Electronic Fundamentals And Applications: Integrated And Discrete Systems. A Pitman International Text. Prentice-Hall, 1976. Isbn: 9780132513715. Url: <https://books.google.co.in/books?id=Ygftaaaamaaj>.
3. B.G. Streetman And S. Banerjee. Solid State Electronic Devices. Pearson, 2015. Isbn: 9780133356038. Url: <https://books.google.co.in/books?id=-Nnznqeacaaj>.
4. S. Salivahanan And K. Vallavaraj. Electronic Devices And Circuits (For Jntu). Tata Mcgraw-Hill Publishing Company Limited, 2008. Isbn: 9780070606456. Url: <https://books.google.co.in/books?id=4zxupgaacaaj>.
5. W.D. Stanley. Operational Amplifiers With Linear Integrated Circuits. Pearson Education, 2002. Isbn: 9788131708453. Url: <https://books.google.co.in/books?id=1eyh3gguh5kc>.
6. A.S. Sedra Et Al. Microelectronic Circuits. Oxford Series In Electrical And Computer Engineering. Oxford University Press, 2020. Isbn: 9780190853549. Url: <https://books.google.co.in/books?id=Vlwhygeacaaj>.
7. U. Tietze, C. Schenk, And E. Gamm. Electronic Circuits: Handbook For Design And Application. Electronic Circuits. Springer Berlin Heidelberg, 2015. Isbn: 9783540786559. Url: <https://books.google.co.in/books?id=Clqvcwaaqbaj>.
8. S.M. Sze. Semiconductor Devices: Physics And Technology, 2nd Ed. Wiley India Pvt. Limited, 2008. Isbn: 9788126516810. Url: [https://books.google.co.in/books?id=D\\_J0znhjuvic](https://books.google.co.in/books?id=D_J0znhjuvic).
9. M.H. Rashid. Microelectronic Circuits: Analysis And Design. Cengage Learning, 2016. Isbn: 9781305642805. Url: <https://books.google.co.in/books?id=2tfqjgeacaaj>.
10. T.L. Floyd. Electronic Devices (Conventional Current Version). Pearson Education, 2017. Isbn: 9780134414577. Url: <https://books.google.co.in/books?id=Oep-Zqeacaaj>.

## **COURSE NAME: Quantum Mechanics**

**COURSE CODE: PY- CE - 6314**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to impart broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation has been discussed along with its applications.*

Course Learning Outcome:

**CLO – 01:** *The learner will receive a broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation which is one of the important equation for studying quantum mechanical systems will be learned along with other aspects like operator formalism of quantum mechanics, principle of uncertainty and complementarity, etc.*

**CLO – 02:** *He will learn to apply the formalism learned so far to investigate quantum mechanical systems like simple harmonic oscillator, hydrogen atom, etc.*

**CLO – 03:** *This knowledge will help in understanding other branches in Physics like Solid State Physics, Nuclear Physics, Spectroscopy, etc*

#### **Unit I - Origin of Quantum Theory (15 lectures)**

Origin of Quantum Theory - Inadequacy of classical physics, Planck's quantum hypothesis, Photo electric effect, Compton effect, Wave-particle duality - de-Broglie hypothesis and genesis of Quantum Mechanics, Verification of matter wave - Davisson-Germer's experiment, G. P. Thomson's electron diffraction experiment (qualitative idea only).

Uncertainty and complementarity - Heisenberg's uncertainty principle and complementarity principle of Neil Bohr, limitations on experiment.

#### **Unit II - Schrödinger's equation (12 lectures)**

Development of the wave equation, time dependent Schrödinger's equation, Statistical interpretation wave function, probability current density, expectation value and operator, Ehrenfest's theorem, Time independent Schrödinger's equation, stationary states, energy quantisation, properties of energy eigen function, General solution of time dependent Schrödinger's equation for time independent potential. Schrödinger's equation in momentum space.

#### **Unit III - Postulates of Quantum Mechanics (5 lectures)**

Postulates of quantum mechanics, observables, hermitian operators, eigenvalues and eigenfunction, uncertainty principle (including time and energy), commuting observables and compatibility.

#### **Unit IV - Application of Schrödinger's equation in one dimensional potential well (13 lectures)**

Schrödinger's equation in one dimensional step potential, potential barrier - reflection and transmission coefficients and tunneling effect, square well potential with infinite depth, one dimensional harmonic oscillator.

## PRACTICAL

### Total Lectures: 30

#### List of Experiments

1. Find the energy eigen values and corresponding normalized wave functions of a particle in a square well potential of infinite depth.
2. Find the energy eigen values and corresponding normalized wave functions of a particle in a square well potential of finite depth.
3. Find the energy eigen values and corresponding normalized wave functions of a simple harmonic oscillator.
4. Solve the s-wave Schrödinger equation for the ground state and the first excited state of the hydrogen atom

$$\frac{d^2u}{dr^2} = A(r)u(r),$$

$$A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

$$\text{where, } V(r) = -\frac{e^2}{r}$$

where,  $m$  is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is  $\approx -13.6$  eV. Take  $e = 3.795(\text{eV})$ ,  $\hbar c = 1973$  (eV) and  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>.

5. Solve the s-wave Schrödinger equation for the ground state and the first excited state of the hydrogen atom

$$\frac{d^2u}{dr^2} = A(r)u(r),$$

$$A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

$$\text{where, } V(r) = -\frac{e^2}{r} e^{-r/a}$$

where,  $m$  is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is  $\approx -13.6$  eV. Take  $e = 3.795(\text{eV})$ ,  $\hbar c = 1973$  (eV) and  $m = 0.511 \times 10^6$  eV/c<sup>2</sup>.

6. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom

$$\frac{d^2u}{dr^2} = A(r)u(r),$$

$$A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

The anharmonic potential,

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose  $m = 940\text{MeV}/c^2$ ,  $k = 100\text{MeV fm}^{-2}$ ,  $b = 0, 10, 30\text{ MeV fm}^{-3}$ . In these units,  $c\hbar = 940\text{MeV}/c^2$ ,  $k = 100\text{MeV fm}^{-3}$  for all three cases. The ground state energy is expected to lie in between 90 and 110 MeV for all three cases.

7. Solve the s-wave Schrodinger equation for the hydrogen molecule

$$\frac{d^2u}{dr^2} = A(r)u(r),$$

$$A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

where,  $\mu$  is the reduced mass of the two-atom system for the Morse potential.

$$V(r) = D(1 - 2e^{-\alpha r'} + e^{-2\alpha r'})$$

$$r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take  $m = 940 \times 10^6\text{ eV}/c^2$ ,  $D = 0.755501$ ,  $\alpha = 1.44$  and  $r_0 = 0.131349\text{\AA}$ .

#### BOOKS RECOMMENDED:

1. S. Gasiorowicz. Quantum Physics, 3Rd Ed. Wiley India Pvt. Limited, 2007. ISBN: 9788126511174. URL: <https://books.google.co.in/books?id=qFtQiVmjWUEC>.
2. B.H. Bransden and C.J. Joachain. Quantum Mechanics. Prentice Hall, 2000. ISBN: 9780582356917. URL: <https://books.google.co.in/books?id=e57kxQEACAAJ>.
3. Nouredine Zettili. Quantum mechanics: concepts and applications. John Wiley & Sons, 2009.
4. David J Griffiths and Darrell F Schroeter. Introduction to quantum mechanics. Cambridge university press, 2018.
5. A.K. Ghatak and S. Lokanathan. Quantum Mechanics: Theory and Applications. Macmillan Publishers India Limited, 2004. ISBN: 9781403923417. URL: <https://books.google.co.in/books?id=PlZKUT3veHUC>.
6. G Arul dhas. Quantum mechanics. PHI Learning Pvt. Ltd., 2008.
7. Joshua Izaac and Jingbo Wang. Computational quantum mechanics. Springer, 2018.

**COURSE NAME: Condensed Matter Physics**

**COURSE CODE: PY- CE - 6324**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

Course Objective:

*Here, the objective is to give learners a broad overview of matter in solid state with different aspects like mechanical, electrical and dielectric properties as well as the forces that bind them together.*

Course Learning Outcome:

**CLO – 01:** *One will learn the main features of crystal lattices and their bondings, classifications of materials in terms of their electric properties.*

**CLO – 02 :** *One learns to apply the concept material properties to measure conductivity, Hall coefficient, and carrier concentration in a material.*

**CLO – 03 :** *The knowledge of material properties will help in developing computer codes to further study wide variety of materials.*

**CLO – 04 :** *Till now, the most important subfield of solid state physics in the 20th century is the study of semiconductors and solid state electronics. This course promises to give background knowledge in pursuing advanced-level studies in semiconductor and solid state electronics.*

**Unit I - Crystal Structure (10 lectures)**

Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

**Unit II - Crystal bonding (5 lectures)**

Ionic, covalent, metallic, Van der Waal and hydrogen bondings, cohesive energy of ionic crystal, Madelung constant.

**Unit III - Free Electron Theory of Metals (12 lectures)**

Electrical and thermal conductivity of metals, Wiedemann-Franz law. Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4-probe method) & Hall coefficient.

**Unit IV - Specific Heat of Solids (6 lectures)**

Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.

**Unit V - Dielectric and Ferroelectric Properties of Materials (12 lectures)**

Polarisation, Depolarisation field, Electric susceptibility, Polarizability, Clausius-Mosotti equation, Langevin-Debye equation, Dielectric constant and dielectric loss, Normal and anomalous dispersion,

Basic idea about piezoelectric, pyro- electric, ferroelectric and electstrictive effects, Curie-Weiss law, Ferroelectric domains and PE hysteresis loop. Plasma oscillations and frequency.

## **PRACTICAL**

### **Total Lectures: 30**

#### List of Experiments

#### *Minimum number of experiments to be performed is four*

1. To study a powder X-Ray diffraction data and to determine the lattice parameters, crystalline size, and interplanar distance. (XRD data needs to be arranged by the Department)
2. To determine the Coupling Coefficient of a Piezoelectric crystal.
3. To measure the Dielectric Constant of a dielectric Materials.
4. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR).
5. To determine the refractive index of a dielectric layer using SPR.
6. To study the PE Hysteresis loop of a Ferroelectric Crystal.
7. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method and to determine its band gap energy.
8. To determine the Hall coefficient and carrier concentration of a semiconductor sample.

### **BOOKS RECOMMENDED:**

1. C. Kittel. Kittel's Introduction to Solid State Physics. Wiley, 2018. ISBN: 9781119456186.  
URL: <https://books.google.co.in/books?id=WHP2DwAAQBAJ>.
2. A.J. Dekker. Solid State Physics. Prentice-Hall technical books. Prentice-Hall, 1965.  
URL: <https://books.google.co.in/books?id=TkRRAAAAMAAJ>.
3. S.O. Pillai. Modern Physics and Solid State Physics (Problems and Solutions). New Age International (P) Limited, 2008. ISBN: 9788122422818.  
URL: <https://books.google.co.in/books?id=Uq4HCuHpwwkC>.
4. N.W. Ashcroft and N.D. Mermin. Solid State Physics. HRW international editions. Holt, Rinehart and Winston, 1976. ISBN: 9780030839931.  
URL: <https://books.google.co.in/books?id=1C9HAQAAIAAJ>.

## **COURSE NAME: Atomic And Nuclear Physics**

**COURSE CODE: PY- CE - 6334**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to provide broad overview of atomic structure and its behaviour in electric and magnetic field. In this course, a broad overview of the constituents of nucleus, the basic force which binds these constituents together and its stability will be given. The phenomenon of radioactivity will also be covered.*

**Course Learning Outcome:**

**CLO – 01:** *The learner will learn about the structure of atom and its behaviour in electric and magnetic field.*

**CLO – 02:** *The learner will learn the constituents of nucleus and the force which binds them together. They will learn about binding energy and understand the concept of stability of nucleus and the cause of radioactivity.*

**CLO – 03:** *This knowledge will help them in future study and doing R&D jobs. The knowledge of nuclear physics will make them competent to pursue a career in radiological physics, nuclear power plant, etc.*

#### **Unit I - Discovery of Charged Particles (4 lectures)**

Detection of Charged particles,  $e/m$  of the electron, Positive Ray Analysis: Thompson's Parabola method.

#### **Unit II - X-Rays (4 lectures)**

Ionizing power, X-ray Diffraction, Bragg's Law, Bohr's Atomic Model, Critical Potentials, X-Ray spectra - continuous and characteristic spectra, Mosley's Law.

#### **Unit III - Atoms in Electric and Magnetic Fields (12 lectures)**

Electron Angular Momentum, magnetic moment, Larmor's Theorem, Spin Magnetic Moment, Pauli's exclusion principle; Spin-orbit interaction - LS and JJ couplings; Spectroscopic notation; Normal and Anomalous Zeeman effect; Paschen Bach effect; Stark effect (qualitative study only); Stern-Gerlach experiment.

#### **Unit IV - General properties of atomic nuclei and its stability (13 lectures)**

Constituents of nucleus and their Intrinsic properties - quantitative facts about mass, radii, charge density, matter density, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

Binding energy, the variation of binding energy per nucleon against mass number, the main features of B.E/A vs. mass number curve, mass defect and packing fraction, Nuclear stability, Nuclear force and its characteristics, Yukawa's meson field theory.

Liquid drop model and Shell model of nucleus (qualitative discussion only), Bethe-Weizsäcker's semi-empirical mass formula, applications - estimation of the mass number of the most stable nucleus in an

isobaric family, estimation of fission energy.

## Unit V - Radioactive Decay (12 lectures)

Radioactive decay - decay rate, secular and transient equilibrium.

Alpha decay - range, energy, straggling of alpha particles, Geiger-Nuttall law, alpha disintegration energy, Spectrum of alpha particles, Gamow's theory of alpha decay (qualitative idea only).

Beta decay - condition of spontaneous beta decay, beta particle spectrum, Pauli's neutrino hypothesis, Fermi theory of beta decay (qualitative idea only), K-electron capture. Gamma decay - origin and energy spectrum, interaction of gamma radiation with matter.

## PRACTICAL

### Total Lectures: 30

List of Experiments

*Minimum number of experiments to be performed is five.*

1. To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
2. To setup the Millikan oil drop apparatus and determine the charge of an electron.
3. To determine the value of Boltzmann Constant by studying Forward Characteristics of a Diode.
4. To determine the value of Planck's Constant by using a Photoelectric Cell.
5. To determine the value of Planck's Constant by using LEDs of at least 4 Different Wavelengths.
6. To measure Planck's constant using black body radiation and photo-detector.
7. To determine the wavelengths of Hydrogen spectrum and hence to determine the value of Rydberg's Constant.
8. To determine the ionization potential of mercury
9. To determine the Wavelength of H-alpha Emission Line of Hydrogen Atom.
10. To study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
11. To study of counting statistics using background radiation using GM counter

### BOOKS RECOMMENDED:

1. A. Beiser. Concepts of Modern Physics. McGraw-Hill higher education. McGraw-Hill, 2003. ISBN: 9780072448481. URL: <https://books.google.co.in/books?id=hjStQgAACAAJ>.
2. J.B. Rajam. Atomic Physics. S. Chand & Company Pvt. Limited, 1974. URL: <https://books.google.co.in/books?id=1J9QtQEACAAJ>.
3. SN Ghoshal. Atomic Physics. S. Chand Limited, 2007. ISBN: 9788121910958. URL: <https://books.google.co.in/books?id=d85dWSbWpOkC>.
4. S.B. Patel. Nuclear Physics: An Introduction. Wiley, 1991. ISBN: 9788122401257. URL: <https://books.google.co.in/books?id=aMzuEby4fX4C>.
5. Krane, Kenneth. S. Introductory Nuclear Physics. Wiley India, 2008. ISBN: 9788126517855. URL: <https://books.google.co.in/books?id=mkZjC1TLXh8C>.

6. SN Ghoshal. Nuclear Physics. S. Chand Limited, 1997. ISBN: 9788121904131. URL: [https://books.google.co.in/books?id=fkqHNMd\\_248C](https://books.google.co.in/books?id=fkqHNMd_248C).
7. V.K. Mittal, R.C. Verma, and S.C. Gupta. Introduction To Nuclear And Particle Physics, Fourth Edition. PHI Learning Pvt. Ltd., 2018. ISBN: 9789387472624. URL: <https://books.google.co.in/books?id=4JNuDwAAQBAJ>.
8. A. B. Gupta. Modern Atomic and Nuclear Physics. New Age International, 2009. ISBN: 9788187134220.

**COURSE NAME: Digital Electronics**

**COURSE CODE: PY- CE - 6344**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

Course Objective:

*This course aims at giving exposure to various types of digital circuits and application of Boolean algebra for simplification of the logic circuits.*

Course Learning Outcome :

**CLO – 01:** *At the end of the course, a learner will have a broad exposure of different types of digital circuits and their applications.*

**CLO – 02:** A learner will know the basic knowledge of integrated circuit and its types and working process of computers

**Unit - I Integrated Circuits (3 lectures)**

Necessity of integrated circuits (ICs). Active and Passive Components. Concept of Wafer and Chip. Advantages and limitations of using ICs. Scale of integration: SSI, MSI, LSI, VLSI and ULSI (basic idea and definitions only). Classification of ICs: based on operating state, based on construction, based on use.

**Unit - II Digital Circuits (8 lectures)**

Difference between analog and digital circuits. Binary Numbers, Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Basic logic gates using diodes and transistors: OR, AND and NOT Gates. Universal Gates: NAND and NOR Gates, XOR and XNOR Gates and application as Parity Checkers.

**Unit - III Boolean Algebra (8 lectures)**

De Morgan's Theorems, Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Maxterms, Conversion of Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

**Unit - IV Arithmetic Circuits (5 lectures)**

Binary Addition. Binary Subtraction using 2's Complement, Half and Full Adders and Subtractors, 4-bit binary Adder/Subtractor.

**Unit - V Sequential Circuits (5 lectures)**

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. Master Slave JK Flip-Flop.

**Unit - VI Timer Circuits (4 lectures)**

Block diagram and working of an IC-555 timer. Astable and monostable multivibrators.

**Unit - VII Shift Registers (up to 4-bits only) (4 lectures)**

Introduction to shift registers. Serial-in-Serial-out, Serial-in-Parallel-out. Parallel-in-Serial-out and Parallel-in Parallel-out Shift Registers.

## **Unit - VIII Counters (up to 4-bits only) (4 lectures)**

Introduction to counters. Propagation delay and frequency division of a counter. Asynchronous counters. Ring counter. Basic ideas about synchronous counter and decade counter.

## **Unit - IX Computer Organization (4 lectures)**

Block diagram of a computer and its units. Input and Output Devices. Data storage devices (idea of RAM and ROM). Computer memory. Memory and its types. Memory organization & addressing.

## **PRACTICAL**

**Total Lectures: 30**

### **List of Experiments**

*Minimum number of experiments to be performed is eight.*

1. To design a switch (NOT gate) using (i) a PNP transistor and (ii) an NPN transistor.
2. To verify and design AND, OR, NOT, and XOR gates using NAND gates.
3. To verify De Morgan's Theorems using ICs.
4. To design a combinational logic system for a specified Truth Table.
5. To convert a Boolean expression into a logic circuit and design it using logic gate ICs.
6. To design a Half Adder and Full Adder using ICs.
7. To design a 4-bit binary Adder using ICs.
8. To design Half Subtractor and Full Subtractor using ICs.
9. To design Adder-Subtractor using Full Adder IC.
10. To build a D flip-flop circuit using NAND gates.
11. To build a JK flip-flop circuit using NAND gates.
12. To build JK Master-slave flip-flop using flip-flop ICs.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To build SR flip-flop circuit using NAND gates.
15. To design an astable multivibrator of given specifications using 555 Timer.
16. To design a monostable multivibrator of given specifications using 555 Timer.

## **BOOKS RECOMMENDED**

1. D.P. Leach Et Al. Digital Principles & Applications. Tata Mcgraw-Hill, 2010. ISBN: 9780071321402. URL: <https://Books.Google.Co.In/Books?Id=Pbwktqeacaaj>.
2. A.A. Kumar. Fundamentals Of Digital Circuits. Prentice Hall India Pvt., Limited, 2016. ISBN: 9788120352681. URL: <https://books.google.co.in/books?id=CyavDAAAQBAJ>.
3. G.K. Kharate. Digital Electronics. OUP India, 2012. ISBN: 9780198061830. URL: <https://books.google.co.in/books?id=MwmscQAACAAJ>.
4. Digital Circuits and Systems. McGraw-Hill Education (India) Pvt Limited, 2011. ISBN: 9780071072700. URL: <https://books.google.co.in/books?id=zZpHzwEACAAJ>.
5. R.J. Tocci, N.S. Widmer, and G.L. Moss. Digital Systems: Principles and Applications.

- Pearson Prentice Hall, 2007. ISBN: 9780131725799.  
URL: [https://books.google.co.in/books?id=4F\\_KPwAACAAJ](https://books.google.co.in/books?id=4F_KPwAACAAJ).
6. S.P. Vingron. Logic Circuit Design: Selected Topics and Methods. Springer International Publishing, 2023. ISBN: 9783031406737.  
URL: <https://books.google.co.in/books?id=WADmEAAAQBAJ>.
  7. S. Ghoshal. Digital Electronics. Blue Kingfisher, 2012. ISBN: 9788131518076.  
URL: <https://books.google.co.in/books?id=-zPpsgEACAAJ>.
  8. S.K. Mandal. Digital Electronics: Principles and Applications. Tata McGraw Hill, 2010. ISBN: 9780070153820. URL: <https://books.google.co.in/books?id=TCRHzwEACAAJ>.
  9. Modern Digital Electronics 4E. McGraw-Hill core concepts in electrical engineering series. McGraw-Hill Education (India) Pvt Limited, 2010. ISBN: 9780070669116. URL: <https://books.google.co.in/books?id=KD5HzwEACAAJ>.
  10. P.B. Zbar, A.P. Malvino, and M.A. Miller. Basic Electronics: A Text-lab Manual. Basic electricity-electronics series. McGraw-Hill Pub., 1990. ISBN: 9780071009867. URL: <https://books.google.co.in/books?id=WsVIPgAACAAJ>.

## **Course Title: Research Methodology in Physics**

**Course Code: PY-CE-7414**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*The objective of the course is to acquaint the learner regarding the fundamentals of research, quantitative and qualitative methods, research philosophy, literature survey, research metrics and publication ethics. It addresses methodological and conceptual issues, research techniques, data management, analysis, and interpretation in physical sciences. The learner will also get knowledge about the methods of writing a research article and presentation techniques of research in a scientific events.*

### **Course Learning Outcome:**

**CLO-01:** Upon completion of this course, students will be able to review literature and formulate research problems by following the research ethics.

**CLO-02:** Upon completion of this course, students will have the proficiency in writing scientific reports/research proposals and present the research on PowerPoint or poster format in a scientific community.

**CLO-03:** The learner will get Knowledge of software tools for data analysis and interpretation in physical sciences research.

**CLO-04:** Upon completion of this course, students will get basic ideas about designing a research problem and its execution in a scientific manner.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

### **Unit I: Introduction to Research methodology**

**(Lectures 08)**

- Introduction, Meaning of Research, Reasons behind doing Research, Objectives of Research, Characteristics of Research.
- Types of Research: Descriptive Versus Analytical, Applied Versus Fundamental, Quantitative Versus Qualitative, Normal Versus Revolutionary, Conceptual Versus Empirical, Other Types of Research.

- Research Methods and Research Methodology, Importance of Research methodology, Reproducibility of Research Work.

## **Unit II: Literature Survey and Research Ethics**

**(Lectures 07)**

- Review of the literature- searching the existing literature, developing a theoretical and conceptual framework, writing about the literature reviewed, Procedure for reviewing the literature, Explore the available literature: Books, Journals, Articles, Electronic Sources of Literature.
- Preparation of a short report.
- Author identifiers/or profiles: ORCID, Publons, Google Scholar, Research Gate, VIDWAN.
- Research Ethics, Misconduct, and COPE guidelines, Plagiarism: Meaning and Necessity, Self-plagiarism, AI-Humanised checking.
- Weightage of research, Importance of Citation, References, Impact factor, Cite Score, h-index, i-index, Almetrics, Citation index, Quartile (Q1, Q2, Q3 and Q4) journals in a particular field.

## **Unit III: Scientific Research Presentations**

**(Lectures 12)**

- I. Research presentation platforms: paper, article, seminar, conference, symposium, workshops, Webinars etc.
- II. Research presentation methods: Oral (talk) and Poster, Model exhibition, Hands-On-Training programs, Panel Discussions, Webinars, Academic Blogs.
- III. Types of research papers and articles: Regular article, Review Article, Letter, Reports, Technical Notes, Conference Papers, Book Chapters, Thesis, Dissertation, Editor's choice etc.
- IV. Writing a research paper and report by using LaTeX or Word file: Title, Abstract, Introduction, Motivation, Scientific Problem, Methodology, Experimental Set-up (if any), Data Analysis and interpretation, Figures with caption, Tables, Footnotes, Results and Discussion, Conclusions, Referencing formats and bibliography management, Acknowledgement, Data availability statement, Conflict of Interest, Graphical Representation and Highlights.
- V. Presentation of research by using power point or Beamer: Title, Contents, Outline of the talk, Motivation, Main contents, Figures with captions, Tables, Footnotes, References.

## **Unit IV: Data Interpretation and Analysis in Physics**

**(Lectures 18)**

- I. Types of Data, Methods of data collection: survey, Observation, Experimentation, Representation of Data: Tabular and diagrammatic methods (Charts/Pie-Chart/Bar diagram), Measurement and Scaling Techniques, Measurement Scales: Nominal, Ordinal, Interval, Ratio, Sources of Error in Measurement, Numerical and Instrumental Errors, Error analysis, Significant Digits.

- II. Graphical Data handling by using any software as mentioned herewith: Origin/Microsoft Excel/GNUPLOT/Python: Background handling, Curve fitting using linear and non-linear regression, Gaussian Curve Fitting, Least squares fit to a polynomial, Goodness of a fit,  $\chi^2$  test, Graphs of two dimension and Three dimension, Plot the graph for proper format for a research article or presentation.
- III. Calibration Methods, Importance of Calibration in Research, Role of Simulation Methods in Research.

### **PRACTICAL: 1 Credit**

**Total Lectures: 30**

*Students will prepare a short report on an article of his/her own choice and give a presentation either in power point template (PPT) or Poster mode covering all the knowledge of the following practical.*

1. Take data from any easily available experimental physics database. Use a proper software to plot the data, perform necessary fittings, estimate the value of  $\chi^2$  and present the data with relevant information.
2. Review any research paper related to Physics thoroughly, create an abstract of your own version, give a suitable alternate title, and find out the highlights, motivation, and major findings of the research paper. Write all the components in the following order (i) Title, (ii) Authors Name, (iii) Affiliation, (iv) Abstract, (v) Highlights, (vi) Motivation, and (vii) Major Findings using LaTeX or any other commercially available software.
3. Review any research paper related to physics thoroughly and give an oral presentation of the research paper based on your understandings.
4. Review any research paper related to Physics thoroughly and prepare a scientific Poster of the research paper based on your understandings and present the poster.
5. Review a research article in the relevant field and preparation of a short report with proper citation and references using LaTeX or any other commercially available software.
6. Student can choose a short-project, study it with proper literature review, design and execute the project, write a report and present an oral presentation at the successful end of the project.
7. Students prepare a list of at least ten journals which have impact factor more and less than 5 from different domains of physics. Identify the Q1 and Q2 journals from the as-prepared list. Write the citation/reference style of a research article from each journal.

### **BOOKS RECOMMENDED**

1. Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.

2. Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3. Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education.
4. Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill.
5. Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
6. Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
7. Research Methods for Science, M. P. Marder, Cambridge University Press, 2011.
8. Research Methodology Techniques and Trends, Y. K. Singh and R. B. Bajpai, APH Publishing Corporation House, 2008.
9. Mathematica by Examples, revised edition, Martha L Abell and James P Braselton, AP Professional, Boston, 1994.
10. Mathematica for the sciences by Richard E Crandall, Addison-Wesley Pub. Co. Inc. 1991.
11. LATEX for Engineers and Scientists by David J Buerger, McGraw Hill Pub. Co., NY, 1990.

## **Course Title: Electromagnetic Theory**

**Course Code: PY-CE-7424**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*This core course develops the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic (EM) waves in vacuum and different media.*

### **Course Learning Outcome:**

**CLO-01:** At the end of the course, a learner will have a broad exposure to properties of electromagnetic waves.

**CLO-02:** Upon completion of this course, the student will be able to apply Maxwell's equations for different derivations for understanding the properties of electromagnetic waves.

**CLO-03:** A learner will know the basic knowledge of propagation of electromagnetic waves and practical applications of electromagnetic waves.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Maxwell Equations**

**(Lectures 08)**

Maxwell's equations, Displacement current, Vector and Scalar potentials, Gauge transformations: Lorentz and Coulomb Gauge, Electromagnetic potentials, Gauge transformation, Gauge invariance, Poynting's theorem, Electromagnetic energy density, Physical concept of electromagnetic field energy density.

#### **Unit II: EM Wave Propagation in Unbounded Media**

**(Lectures 10)**

Plane EM waves through vacuum and isotropic dielectric medium, Transverse nature, Refractive index, Dielectric constant, Wave impedance, Plane EM waves through conducting medium: Relaxation time, Skin depth, Attenuation constant, Wave propagation through dilute plasma: Electrical conductivity of ionized gases, Plasma frequency, Refractive index, Skin depth.

### **Unit III: EM Waves in Bounded Media**

**(Lectures 08)**

Boundary conditions at a plane interface between two media, Reflection & refraction of plane EM waves at plane interface between two dielectric media-Laws of reflection & refraction, Fresnel's formulae for perpendicular & parallel polarization, Brewster's law, Reflection & Transmission coefficients, Total internal reflection.

### **Unit IV: Polarization of EM Waves**

**(Lectures 12)**

Propagation of EM waves in an anisotropic media, Symmetric nature of dielectric tensor, Fresnel's formula, Uniaxial and biaxial crystals, Light propagation in uniaxial crystal, Polarization by double refraction, Linear, Circular and Elliptical Polarization, Ordinary & extraordinary refractive indices, Production & detection of Plane, Circularly and Elliptically Polarized light, Phase retardation plates: Quarter-wave and Half-wave plates, Babinet Compensator and its uses.

Biot's laws for rotatory polarization, Fresnel's theory of optical rotation, Experimental verification of Fresnel's theory.

### **Unit V: Wave Guides**

**(Lectures 07)**

Planar optical wave guides (TE mode), Planar dielectric wave guide (TE mode), Condition of continuity at interface, Phase shift on total reflection, Eigenvalue equations, Phase and group velocity of guided waves, Field energy and power transmission.

### **TUTORIAL: 1 Credit**

#### **Total Lectures: 15**

Tutorial classes will be taken on the topics above based on the needs of the students.

#### **BOOKS RECOMMENDED**

1. Introduction to Electrodynamics, D.J. Griffiths, Cambridge University Press.
2. Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning.
4. Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5. Engineering Electromagnetic, William H. Hayt, 8th Edition, 2012, McGraw Hill.
6. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
7. Electromagnetic Field and Waves, P. Lorrain and D. Corson, W. H. Freeman & Company
8. Classical Electrodynamics, J.D. Jackson, Wiley.
9. Principle of Optics, M. Born and E. Wolf, Pergamon Press.

10. Optics, (2017), Ajoy Ghatak, McGraw-Hill Education, New Delhi.
11. Problems and solution in Electromagnetics, Ajoy Ghatak, K Thyagarajan & Ravi Varshney.
12. Electromagnetics, J.A. Edminster, Schaum Series, Tata McGraw Hill.

## **Course Title: Advanced Classical Mechanics**

**Course Code: PY-CE-7434**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*Classical mechanics aims to provide a foundational understanding of the physical laws that govern motion and forces in the macroscopic world. It equips learners with the ability to analyse and predict the behaviour of particles and rigid bodies using principles such as Newton's laws, conservation laws, and advanced formulations like Lagrangian, Hamiltonian mechanics and also through canonical transformation equations.*

### **Course Learning Outcome:**

**CLO-01:** Upon successful completion of a Classical Mechanics course, students will be able to apply Newtonian, Lagrangian, and Hamiltonian formulations to analyse the motion of particles and rigid bodies in various physical systems.

**CLO-02:** Students will be able to generalise the laws of physics in higher dimensions, and will be able to apply the formalism of classical mechanics to more advanced frameworks.

**CLO-03:** Learners will also gain the ability to model real-world phenomena using mathematical tools, appreciate the limitations of classical theories, and transition smoothly into more advanced topics such as quantum mechanics and relativity.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Canonical transformation and Hamilton-Jacobi theory (Lectures 14)**

Liouville's theorem, Poisson's brackets and their properties, Canonical transformations and generating function; Hamilton's equation in terms of Poisson bracket, Hamilton's Jacobi theory and its application to harmonic oscillator problem; Action-angle variables and application to simple harmonic oscillator and planetary motion- orbital degeneracy.

## Unit II: Small oscillations

(Lectures 09)

Small oscillations and equilibrium- stable, unstable and neutral, Minimum of potential energy, Expansion of potential energy, Equation of motion of small oscillation, Normal modes and Coupled oscillations, Kinetic and potential energy matrices, Small oscillations in normal coordinates-two coupled oscillators, double pendulum, Diatomic and triatomic molecules, Transverse oscillations of N-coupled masses.

## Unit III: Theory of scattering

(Lectures 06)

Scattering angle and impact parameter, scattering cross-section, Generalization of scattering, Differential scattering cross-section, Scattering of a particle by a hard sphere- Rutherford scattering, Cross section among various frames of references-Centre of mass and Laboratory System of Scattering.

## Unit IV: Rigid Body Dynamics

(Lectures 08) Rigid

body dynamics; moment of inertia tensor; non-inertial frames and pseudo forces; Principal axes and principal moments of inertia; Euler's equation of motion; Symmetric top motion and Foucault's pendulum.

## Unit V: Nonlinear Dynamics

(Lectures 08)

- **Introduction to nonlinear systems:** Linear vs. nonlinear response, examples from mechanics and population dynamics.
- **Phase space and trajectories:** Fixed points, limit cycles, and qualitative analysis of nonlinear equations.
- **Bifurcation theory:** classification of bifurcations (saddlnode, pitchfork, Hopf) and their physical interpretation.
- **Deterministic chaos:** sensitivity to initial conditions, Lyapunov exponents, and routes to chaos.
- **Strange attractors and physical examples:** Lorentz system, logistic map, pendulum, and driven oscillators.

## TUTORIAL: 1 Credit

### Total Lectures: 15

Tutorial classes will be taken on the topics above based on the needs of the students.

## BOOKS RECOMMENDED

7. H. Goldstein, C.P. Poole, and J. L. Safko. Classical Mechanics. Addison Wesley, 2002.
8. R.G. Takwale and P.S. Puranik. Introduction to Classical Mechanics. Tata McGraw-Hill, 1980.

9. K.C. Gupta. Classical Mechanics of Particles and Rigid Bodies. Wiley, 1988.
10. N.C. Rana and J.P. Sharadchandra. Classical Mechanics. Tata Mac Graw Hill, 1991.
11. S. N. Biswas. Classical Mechanics. Books & Allied Limited, 2014.
12. L. D. Landau and E. M. Lifshitz. Mechanics: Volume 1. v. 1. Elsevier Science, 1982.
13. S. H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press.
14. E. Ott, Chaos in Dynamical Systems, Cambridge University Press.
15. R. C. Hlborn, Chaos and Nonlinear Dynamics, Oxford University Press.

# **Course Title: Electronic Devices and Communications**

**Course Code: PY-CE-7444**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **Course Objective:**

*The objective of the course is to acquaint the learner regarding the various electronic devices and their working. The learner will also get knowledge about the need of the modulation process in the communication technology. In addition, students will get a hands-on-training on related experiments and analyse the experimental data.*

## **Course Learning Outcome:**

**CLO-01:** Upon completion of this course, students will be able to gain knowledge on advanced electronics devices such as power supply, active filters, UJT, JFET, MOSFET, PLL etc.

**CLO-02:** After ending of this course, students will have the concepts of electronics in communication, details of communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK.

**CLO-03:** The learner will get knowledge on phase locked loop and it's applications in modern day's communication systems.

**CLO-04:** Upon completion of this course, students will get hands-on experience on working of various electronic devices and their industrial uses.

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## **THEORY: 3 Credits**

**Total Lectures: 45**

### **Unit I: Electronic Devices**

**(Lectures 20)**

- (i) Clipper and clamper circuits using diode, Block diagram of a power supply, Qualitative idea of C and L filters. IC regulators, Line and load regulation.
- (ii) Basics and diagram of active filter, Critical frequency and roll-off rate, Low pass, High pass, Band pass, and Band reject filters, Different order filters.
- (iii) Astable and monostable multivibrators using transistors and their characteristics.

- (iv) Metal-semiconductor Junction, Metal oxide semiconductor (MOS) devices, SiO<sub>2</sub>-Si based MOS, JFET and MOSFET–their frequency limits. Enhancement and depletion mode MOSFETS, Characteristic and small signal equivalent circuits of UJT and its use as a simple relaxation oscillator.
- (v) Digital to analog conversion (DAC): Resistive network (Weighted and R–2R ladder), Accuracy and resolution, Analog to digital conversion (ADC): successive approximation.

## **Unit II: Phase Locked Loop (PLL)**

**(Lectures 07)**

Varactor diode and its characteristics, Voltage Controlled Oscillator (VCO), Basic principle of PLL with necessary block diagram, Characteristics of a PLL circuit, Free running frequency, Lock range, Capture range, Basic idea of PLL with IC-565, Applications of PLL.

## **Unit III: Electronic Communication Systems and Processes**

**(Lectures 18)**

- Block diagram of electronic communication system, Need for modulation. Concept of Noise, signal-to-noise (S/N) ratio and its effect in communication, Amplitude Modulation (AM), modulation index and frequency spectrum, Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Frequency Modulation (FM), modulation index and frequency spectrum, Generation of FM using PLL, FM detector (slope detector), Basic ideas about Phase modulations,
- Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, Concept on ASK, FSK, PSK, and BPSK.
- General introduction to satellite communications and GPS system.

## **PRACTICAL: 1 Credit**

**Total Lectures: 30**

## **List of Experiments**

*Minimum number of experiments to be performed is six.*

1. To realize Clipper and clamper circuits using diode. Understanding the waveform change of diode clipping and clamping circuits when the bias is applied.
2. To design a power supply using bridge rectifier and calculate the ripple factor using C-filters.
3. To design a 1st order active Low pass filter and draw the frequency response curve. Also determine the roll off rate of the filter.
4. To design a 1st order active High pass filter and draw the frequency response curve. Also determine the roll off rate of the filter.
5. To design a 1st order active band pass filter and draw the frequency response curve.

6. To design a 1st order active band reject filter and draw the frequency response curve.
7. To study the output and transfer characteristics of a JFET.
8. To design a common source JFET Amplifier and study its frequency response.
9. To study the output characteristics of a MOSFET.
10. To design an astable multivibrator of given specifications using transistor.
11. To study the lock range and capture range of a PLL IC.
12. To study an Amplitude Modulator circuit and to study the envelope detector for demodulation of AM signal.
13. To analyse a FM modulator circuit. Estimate the modulation index and bandwidth. Draw the FM spectra.
14. To analyse a FM demodulation circuit. Estimate the free running signal and the lock range. (Use the circuit for demodulating a FM modulation system)
15. To design PWM, PPM, PAM and Pulse code modulation using ICs.
16. To study ASK, PSK and FSK modulator.
17. To design a digital to analog converter (DAC) of given specifications.
18. To study the analog to digital convertor (ADC) IC.

#### **BOOKS RECOMMENDED**

1. J. Millman. Integrated Electronics: Analog and Digital Circuits and Systems. Mcgraw-Hill Education (India) Pvt Limited, 2010.
2. R. A. Gayakwad, OP-Amps and Linear Integrated Circuit, 4th edition, 2000, Prentice Hall.
3. J. D. Ryder. Electronic Fundamentals and Applications: Integrated and Discrete Systems. A Pitman International Text. Prentice-Hall, 1976.
4. B. G. Streetman and S. Banerjee. Solid State Electronic Devices. Pearson, 2015.
5. S. M. Sze. Semiconductor Devices: Physics and Technology, 2nd Ed. Wiley India Pvt. Limited, 2008.
6. T. L. Floyd. Electronic Devices (Conventional Current Version). Pearson Education, 2017.
7. George Kennedy, Electronic Communication systems, 3rd Edn., 1999, Tata McGraw Hill.
8. Simon Haykin, Communication Systems, Wiley India
9. Andrea Goldsmith, Wireless communications, 2015, Cambridge University Press
10. B. P. Lathi, Modern Analog and Digital Communication.
11. R. P. Jain, Modern Digital Electronics.

# **Course Title: Atomic & Molecular Spectroscopy**

**Course Code: PY-CE-7454**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **Course Objective:**

The objective is to teach the students the basic atomic and molecular (diatomic) structures with quantum mechanical approach leading to their fundamental spectroscopies.

## **Course Learning Outcome:**

**CLO-01:** Students will learn the details of atomic and diatomic molecular (diatomic) structures in terms of quantum mechanical treatment elaborately beyond the basic models.

**CLO-02:** It will give the descriptions of fine structure of atoms and rotational, vibrational and electronic energies of molecules manifesting in their respective spectroscopies.

**CLO-03:** Upon completion of this course, the students will learn the details of these spectroscopies and their impact on understanding the fundamentals for various concerned experimental results.

**CLO-04:** The basic principles of light coherence as laser with their types and variants will also be covered exposing the students to the important modern spectroscopic tool.

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## **THEORY: 3 Credits**

**Total Lectures: 45**

### **Unit-I: Atomic Physics**

**(Lectures 15)**

Fine structure of hydrogen atoms, Mass correction, spin-orbit term, Darwin term. Intensity of fine structure lines. Franck and Hertz's Experiment, Effect of magnetic and electric fields: Zeeman, Paschen-Bach and Stark effects. The ground state of two-electron atoms – perturbation theory and variational methods. Many-electron atoms – Central Field Approximation-LS and JJ coupling schemes, Lande interval rule. The Hartree-Fock equations (quantitative idea). The spectra of alkalis using quantum defect theory. Selection rules for electric and magnetic multipole radiation. Auger process.

## **Unit-II: Molecular Structure**

**(Lectures 08)**

Born-Oppenheimer approximation for diatomic molecules, rotation, vibration and electronic structure of diatomic molecules. Spectroscopic terms. Centrifugal distortion. Electronic structure-Molecular symmetry and the states. Molecular orbital and valence bond methods for  $2H$  and  $H_2$ . Morse potential. Basic concepts of correlation diagrams for heteronuclear molecules.

## **Unit-III: Molecular Spectra**

**(Lectures 22)**

- Rotational spectra of diatomic molecules-rigid and non-rigid rotors, isotope effect, Vibrational spectra of diatomic molecules- harmonic and anharmonic vibrators, Intensity of spectral lines, dissociation energy, vibration-rotation spectra.
- Electronic spectra of diatomic molecules- vibrational structure of electronic transitions (coarse structure)-progressions and sequences.
- Rotational structure of electronic bands (Fine structure)-P, Q, R branches, Fortrat diagram, Intensities in electronic bands-The Franck- Condon principle, the electron spin and Hund's cases.
- Raman Effect: Classical theory of Raman Effect, Vibrational Raman spectrum, selection rules, Stokes and antistokes lines.
- Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR).
- UV-Visible spectra, its importance and applications.
- Introductory idea about photoluminescence spectra.

## **TUTORIAL: 1 Credit**

### **Total Lectures: 15**

Tutorial classes will be taken on the topics above based on the needs of the students.

### **BOOKS RECOMMENDED**

1. Introduction to Atomic Spectra, H. E. White.
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. Mc.
3. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachain.
4. Basic atomic & Molecular Spectroscopy, J. M. Hollas (Royal Society of Chemistry, 2002)
5. Spectra of Diatomic Molecules (Vol. 1), G. Herzberg.
6. Atoms, Molecules and Photons, W. Demtroder (Springer, 2006)
7. Molecular Spectra and Molecular Structure, G. Herzberg (Van Nostrand, 1950).

## **Course Title: Advanced Quantum Mechanics**

**Course Code: PY-CE-8414**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*To know the fundamental principles and mathematical framework of quantum mechanics. To develop problem-solving abilities in quantum dynamics. To learn about approximation methods in quantum systems.*

### **Course Learning Outcome:**

**CLO-01:** Learning the fundamental concepts and mathematical framework of quantum mechanics.

**CLO-02:** Applying quantum mechanical formalisms to solve problems related to system dynamics, angular momentum, and approximation methods.

**CLO-03:** Analyse and evaluate physical systems using quantum models and interpret results in terms of observables.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Mathematical Prerequisites**

**(Lectures 12)**

The Hilbert Space and Wave Functions, Dirac notation - bra and ket vectors, Operators- algebraic properties and matrix representation, representations in discrete and continuous bases.

#### **Unit II: Quantum Dynamics**

**(Lectures 12)**

The basic postulates of quantum mechanics, the state of a system, observables and Operators, Measurement in quantum systems, expectation values and uncertainty relation, time evolution of system's state, Symmetries and conservation laws, Poisson bracket and commutator, the Ehrenfest theorem.

The Schrodinger picture and Heisenberg picture, Heisenberg's equation of motion, Solution of simple harmonic oscillator problem by the operator method.

### **Unit III: Angular Momentum**

**(Lectures 09)**

Angular momentum- eigen values of  $L^2$  and  $L_z$  and the commutation relation, General angular momentum-operator and its matrix representation, eigen values and eigen vectors, Spin angular momentum- spin 1/2 particles and Pauli matrices, Total angular momentum, Clebsch-Gordan coefficient.

### **Unit IV: Approximation Methods**

**(Lectures 12)**

Time independent perturbation theory - non-degenerate case, degenerate cases; Zeeman Effect and Stark effect, Variational methods of approximation, WKB approximation.

Time dependent perturbation theory- time dependent potential and interaction picture, Fermi-Goldon's rule, Adiabatic and Sudden approximation, Interaction with classical radiation field.

**TUTORIAL: 1 Credit**

**Total Lectures: 15**

Tutorial classes will be taken on the topics above based on the needs of the students.

### **BOOKS RECOMMENDED**

1. N. Zettili. Quantum Mechanics: Concepts and Applications. Wiley, 2009.
2. D. J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press.
3. B. H. Bransden and C. J. Joachain. Introduction to Quantum Mechanics. Longman Scientific & Technical, 1989.
4. J. J. Sakurai and J. Napolitano. Modern Quantum Mechanics. Addison-Wesley, 2011.
5. R. Shankar. Principles of Quantum Mechanics. Springer, 2004.
6. S. N. Biswas. Quantum Mechanics. Calcutta Books and Allied Pvt. Ltd., 1998.

## **Course Title: Statistical Mechanics**

**Course Code: PY-CE-8424**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*The main objective is to learn how to derive the macroscopic properties of a system from its microscopic components, using techniques like the ensemble theory and probability. The primary goal is to bridge the gap between the behaviour of individual atoms and molecules (microscopic) and the observable properties of a system like a gas, liquid, or solid (macroscopic).*

### **Course Outcome:**

**CLO-01:** Students would be able to understand the fundamental difference of Classical and quantum statistics and a generalized approach to study both the statistics together.

**CLO-02:** Students will learn to evaluate and interpret the partition function and its significance in relating statistical averages to thermodynamic quantities.

**CLO-03:** On successful completion of the course students will be learn the techniques of Statistical Mechanics to apply in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry and in many other directions.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Classical Statistics**

**(Lectures 17)**

Concept of Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and Grand Canonical Ensemble, Phase Space, Entropy and Thermodynamic Probability, Their relationship, Maxwell-Boltzmann distribution Law, Partition Function, Thermodynamic Functions (Entropy, Helmholtz free energy, Enthalpy etc.) and Partition function of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations. Concept of negative temperature.

#### **Unit II: Classical Theory of Radiation**

**(Lectures 08)**

Properties of Thermal Radiation, Blackbody Radiation and its spectral distribution, spectral distribution curve and temperature dependence, Kirchhoff's Law, Stefan-Boltzmann Law: Thermodynamic proof.

Radiation Pressure, Wien's Displacement Law, Wien's Distribution Law, Saha's Ionization Formula, Rayleigh-Jean's Law, Ultraviolet Catastrophe.

### **Unit III: Quantum Theory of Radiation**

**(Lectures 05)**

Spectral Distribution of Black Body Radiation and need of quantum theory, Planck's Quantum Postulates, Planck's Law of Blackbody Radiation : Experimental Verification, Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law (4) Wien's Displacement Law from Planck's Law. Applications (numerical) of these Laws to Physical dynamics.

### **Unit IV: Bose-Einstein Statistics**

**(Lectures 07)**

Probability distribution for Bose-Einstein Statistics, B-E Distribution Law, Thermodynamic functions of a strongly Degenerate Bose Gas, pressure and Gas degeneracy, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Partition function, Thermodynamic functions of photon gas (Energy, Entropy, Enthalpy, Helmholtz free energy, Gibb's free energy, Derivation of Planck's law from Bose-Einstein distribution law.

### **Unit V: Fermi-Dirac Statistics**

**(Lectures 08)**

Probability distribution for Fermi Dirac Statistics, Fermi-Dirac Distribution Law, Partition function, Thermodynamic functions ( $C_v$ , Entropy, Helmholtz free energy) of a Completely and strongly Degenerate Fermi Gas, Fermi Energy and Fermi temperature, Pressure of Electron gas in a Metal, Specific Heat of Metals and Debye law, Relativistic Fermi gas, White Dwarf Stars and Chandrasekhar Mass Limit.

## **PRACTICAL**

**Total Lectures: 30**

### **List of Programs**

1. Computational analysis of the behaviour of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles  $N$  and the initial conditions:
  - a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations.
  - b) Study of transient behaviour of the system (approach to equilibrium).
  - c) Relationship of large  $N$  and the arrow of time.
  - d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution.

- e) Computation and study of mean molecular speed and its dependence on particle mass.
  - f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function  $Z(\beta)$  for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles  $N$  under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
  - a) Study of how  $Z(\beta)$ , average energy  $\langle E \rangle$ , energy fluctuation  $\Delta E$ , specific heat at constant volume  $C_v$ , depend upon the temperature, total number of particles  $N$  and the spectrum of single particle states.
  - b) Ratios of occupation numbers of various states for the systems considered above.
  - c) Computation of physical quantities at large and small temperature  $T$  and comparison of various statistics at large and small temperature  $T$ .
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
  - a) Maxwell-Boltzmann distribution
  - b) Fermi-Dirac distribution
  - c) Bose-Einstein distribution

## BOOKS RECOMMENDED

1. Statistical Mechanics, R. K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Kerson Huang, Statistical Mechanics, John Wiley and Sons.  
Statistical Mechanics: An Introductory Theory, J. K. Bhattacharjee.
1. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
2. Statistical Mechanics, K K Pathak and Mridula Mishra, 2022, Vishal Publishing Co.
3. Statistical and Thermal Physics, S. Lokanathan and R. S. Gambhir. 1991, Prentice Hall.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. An Introduction to Statistical Mechanics & Thermodynamics, R. H. Swendsen, 2012, Oxford Univ. Press.

## **Course Title: Advanced Condensed Matter Physics**

**Course Code: PY-CE-8434**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*Here, the objective is to give learners a broad overview of matter in solid state with different aspects like structural, magnetic and superconducting properties as well as the forces that bind them together. In addition, students will get a hands-on-training on related experiments and analyse the experimental data.*

### **Course Learning Outcome:**

**CLO-01:** This course provides a foundation for future advanced studies in solids. On successful completion of this course students will be able to learn the fundamental topics in solids such as magnetism and lattice dynamics.

**CLO-02:** Further the students would also be able to acquaint themselves to the nanomaterial's that bridges that the bulk and the atomic world.

**CLO-03:** The learner will develop the skill to solve the experimental problems and analyse the experimental data collected from each experiment and interpret the results.

**CLO-04:** On successful completion of the course students should be able to apply the mathematical and theoretical concepts to analyse and solve problems related to lattice dynamics, magnetic and superconducting properties.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Lattice Dynamics**

**(Lectures 06)**

Quantization of lattice vibration and phonons, Acoustical and optical phonons, Dispersion relations in monoatomic and diatomic linear lattices.

#### **Unit II: Imperfections in Crystalline Solids**

**(Lectures 05)**

Introductory concepts, Point defect, Schottky, Frenkel defects, line defects, disorder, Dislocations, Diffusion, Fick's law.

### **Unit III: Nanomaterials**

**(Lectures 04)**

Introduction to nanomaterials, Properties of nanomaterials, Types of nanomaterials, Basic concepts of 0-D, 1-D, 2-D and 3-D nanomaterials, Surface to volume ratio, Brief idea about soft matters, Applications of nanomaterials.

### **Unit IV: Magnetism in Solids**

**(Lectures 16)**

Origin of magnetism in materials, magnetization, magnetic susceptibility, Classification of magnetic materials (dia, para, ferro, antiferro and ferrimagnetic), Classical Langevin theory of dia and paramagnetism, Curie's law, Weiss's theory of ferromagnetism, Curie-Weiss law, Ferromagnetic domains, Easy and hard axis, Magnetocrystalline anisotropy, Magnetic hysteresis curve and energy loss, Soft and hard magnetic materials, Qualitative idea about Magnetoresistance and its types: AMR, GMR, TMR and CMR, Basic ideas about Spin-glass and spin-liquid states.

### **Unit V: Superconductivity**

**(Lectures 14)**

Properties of superconductors: Critical temperature, critical magnetic field, Meissner effect, Type-I and type-II Superconductors, Qualitative idea about BCS theory, London's Equations and penetration Depth, Thermodynamics of superconductors: Rutger's formula, Heat capacity and energy gap, Isotope effect, Quantum tunnelling effect in superconductors: Josephson effects, Flux quantization in superconductors and SQUID, Concept on high- $T_C$  superconductors.

### **PRACTICAL: 1 Credit**

**Total Lectures: 30**

### **List of Experiments**

*Minimum number of experiments to be performed is six.*

1. To study the dispersion relation for the monoatomic lattice chain.
2. To study the dispersion relation for the diatomic lattice chain.
3. To measure the speed of sound in a metal rod using ultrasonic transducers and relate it to elastic constants and phonon modes.
4. To measure the susceptibility of a paramagnetic solution by using Quinck's Tube Method.
5. To measure the Magnetic susceptibility of Solids by using Guoy method.
6. To draw the B-H curve of Fe using Solenoid and determine the energy loss from the Hysteresis.
7. To determine the coercivity, retentivity, and saturation magnetization of a given ferromagnetic specimen using B-H loop curve.

8. To determine the magnetoresistance of a supplied material for various current values.
9. To determination of Landé g factor using the ESR set-up.

**Use of Computational Software: Origin Prp/Mathematica/Python etc.**

10. To analyse the XRD patterns of bulk vs. nanocrystalline samples and estimate the crystallite size using Scherrer's equation. *(The data should be arranged by the department)*
11. To analyse a given set of temperature or field dependence of resistivity data in a suitable software and calculate the magnetoresistance. Plot the corresponding plots and determine the types of magnetoresistance. *(The data should be arranged by the department)*
12. To analyse a temperature dependent magnetization data, check the Curie or Curie-Weiss law of the data and determine the Curie Constant and Weiss temperature (if any). *(The data should be arranged by the department)*
13. To determine the absorption coefficient and band gap of a given set of UV-Spectroscopy data in a suitable software. *(The data should be arranged by the department)*

***N.B.: The teachers can also design/modify some practical relevant to the content of the course.***

**RECOMMENDED BOOKS**

1. Introduction to Solid State Physics, C Kittel.
2. Lattice Dynamics, A K Ghatak and L S Kothari.
3. Solid State Physics, A J Dekker.
4. Solid State Physics, N W Ashcroft and N D Mermin.
5. Defects in Solids, Richard J. D. Tilley.
6. Magnetism in Condensed Matter, Stephen Blundell.
7. Magnetism in solids, D H Martin.
8. Physics of Magnetism, S Chikazumi.
9. Magnetism and Magnetic Materials, J. M. D. Coey.
10. Solid State Physics, S O Pillai.
11. Introduction to Nanotechnology, C. P. Poole, J. F. J. Owens.

## **Course Title: Advanced Nuclear Physics**

**Course Code: PY-CE-8444**

**Total Credits: 4 (Theory: 3 + Tutorial/Practical: 1)**

### **Course Objective:**

*The objective is to give learners a broad view of nucleus including its and properties. An attempt is taken to make the learner aware of reaction. The students will learn about in-depth description of the nucleus and its different properties. They will also learn to describe the structure of the nucleus, nature of the interaction that occurs inside the nucleus.*

### **Course Learning Outcome:**

**CLO-01:** On successful completion of the course, students will be able to understand the Basic Nuclear Properties: size, shape and charge distribution, spin, parity and isospin of nucleon and nuclei.

**CLO-02:** This course provides a foundation for nuclear structure. On successful completion of this course students will be able to learn about the introductory concepts of nuclear model.

**CLO-03:** The students will learn about in-depth description of the nucleus and its different properties. They will also learn to describe the structure of the nucleus, nature of the interaction that occurs inside the nucleus.

**CLO-04:** The course will develop problem based skills and the acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Nuclear Models**

**(Lectures 08)**

- Fermi gas model: Degenerate fermion gas, nuclear symmetry potential in Fermi gas.
- Shell Model: Magic numbers and experimental evidences of shell models, Single particle shell model and its application in predicting the spin and parity of even A and odd A nuclei, Failures of extreme single particle shell model.
- Collective Model: Basic Concepts.

## **Unit II: Nuclear Reactions**

**(Lectures 10)**

Concept of two body nuclear reaction for fixed target experiments- Flux, Cross-section, Rutherford alpha particle scattering experiment, Energy consideration in Nuclear Reaction, Kinematics of reactions, Mass defect and Q-value of a nuclear reaction, Einstein's mass-energy equivalence principle and generation of nuclear energy. Nuclear Fission: Spontaneous and induced fission, Fission chain reactions and nuclear reactor, Fusion and thermonuclear reactions.

## **Unit-III: Forces between Nucleons**

**(Lectures 05)**

Two nucleon system - bound state problem, Characteristics of nucleon-nucleon interactions, Deuteron as the simplest two body bound system - its ground state spin, parity, magnetic dipole and electric quadrupole moments, Concept of non-central nuclear force.

## **Unit IV: Nuclear Detectors**

**(Lectures 06)**

Current vs. applied voltage curve, detector response, efficiency and resolution of a detector, Ionization chamber, proportional counter, and GM counter – construction and working principle. Scintillator detectors–Working principle of NaI (Tl) scintillator, Construction of photo-multiplier tube (PMT).

## **Unit V: Nuclear Accelerators**

**(Lectures 06)**

Charged particle accelerators, Construction and working principle of linear accelerator (LINAC), Limitations of linear accelerators, Van-de Graaff generator (Tandem accelerator), Concept of Cyclic accelerator, Cyclotron–it's working principle and construction, limitation of Cyclotron, Synchrotron (only concept).

## **Unit VI: Elementary Particles**

**(Lectures 10)**

Classification of elementary particles and their quantum numbers, Allowed and forbidden reactions, Particle interactions-strong, electro-magnetic and weak interactions, Basic features, Types of particles and its families, Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, Gellman-Nishijima scheme, Concept of quark model, Colour quantum number and gluons, Introduction to the Standard model.

## **TUTORIAL: 1 Credit**

## **Total Lectures: 15**

Tutorial classes will be taken on the topics above based on the needs of the students.

## BOOKS RECOMMENDED

1. Nuclear Physics: An Introduction by S. B. Patel. Wiley, 1991.
2. Nuclear Physics by S. N. Ghoshal. S. Chand Limited, 1997.
3. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
4. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
5. Introduction to the physics of nuclei & particles, R. A. Dunlap. (Thomson Asia, 2004).
6. Introduction to High Energy Physics, D. H. Perkins, Cambridge Univ. Press
7. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
8. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
9. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).
10. Radiation detection and measurement, G. F. Knoll (John Wiley & Sons, 2000).
11. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
12. Theoretical Nuclear Physics, J. M. Blatt & V. F. Weisskopf (Dover Pub. Inc., 1991)

## **Course Title: Astronomy & Astrophysics**

**Course Code: PY-CE-8454**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **Course Objective:**

*The objective is to give learners a broad overview of Astrophysics and astronomy. Student will be introduced with fundamental concepts and observational techniques in astronomy including virtual observatory tools. In addition, student will acquire knowledge on the physical processes occurring inside the celestial objects and the physical concepts required for the study of recent frontiers in astrophysics.*

### **Course Learning Outcome:**

**CLO-01:** Upon completion of this course, students will be able to understanding the origin and evolution of the Universe. The course will give a comprehensive idea on the measurement of requisite parameters such as astronomical scales, luminosity and astronomical quantities.

**CLO-02:** On successful completion of this course, the learner will be able to apply physics of celestial objects in understanding the universe.

**CLO-03:** They will be equipped with the skills required for observational astronomy and virtual observatory tools.

**CLO-04:** On successful completion of the course, students will have the understanding of the solar system, origin and evolution of galaxies, presence of dark matter and large scale structures of the Universe.

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### **THEORY: 3 Credits**

**Total Lectures: 45**

#### **Unit I: Basic Astronomy**

**(Lectures 05)**

Flux, Intensity and luminosity of celestial objects, Stellar magnitude scale—apparent and absolute magnitude, Astronomical Filter, Colour Index, Measurement of stellar distances—trigonometric parallax, Introduction to HIPPARCOS and GAIA, Cosmic distance scale: distance ladder.

## **Unit II: Positional Astronomy**

**(Lectures 05)**

Celestial sphere and celestial coordinates systems – Horizontal Co-ordinate system (Altitude-Azimuth) and Equatorial Co-ordinate system (Right Ascension - Declination), Concept of time: solar time, mean solar time, universal time, sidereal time, local sidereal time, Julian day.

## **Unit III: Astronomical Techniques**

**(Lectures 07)**

Telescopes–Different types of optical telescopes (reflecting and refracting); Telescope properties: light gathering power, resolving power, plate scale, Telescope optics: f-number; Space telescopes; Concept of virtual observatory and Virtual observatory tools in astronomy–SIMBAD, Aladin, SDSS, AAVSO, Sky-View (*introduction only*); Introduction to photometry, Spectroscopy and polarimetry; CCD–an introduction.

## **Unit IV: Stellar Astrophysics**

**(Lectures 10)**

Interstellar medium (ISM), Star formation (*introduction only*); Hydrostatic equilibrium, Properties of stars, their determination and relations: mass, luminosity, radius and effective surface temperature, Spectral classification of stars, HR Diagram, Star clusters– open and globular (*introduction only*), Stellar evolution- idea of nucleosynthesis in main sequence phase PP and CNO cycle, Evolution of Sun-like stars off the main sequence -red giants and white dwarfs- Chandrasekhar mass limit, Evolution of massive stars– neutron stars and black holes (*introduction only*).

## **Unit V: Solar System Objects**

**(Lectures 10)**

The Sun and its atmosphere: photosphere, chromospheres and corona, Sunspots, Solar flare, Coronal Mass Ejection (CMEs), Physical properties of planets: Planetary mass, densities, periods, temperatures, and planetary atmospheres, Pluto and dwarf planets, Asteroid belt, Meteorites and Comets, Kuiper belt and Oort cloud, Extra-solar planets and classification (*introduction only*).

## **Unit VI: Galaxies and Cosmology**

**(Lectures 08)**

Galaxies and its classifications: spirals, elliptical, irregular and lenticular, Hubble's tuning fork diagram, Milky Way Galaxy, Introductory concept on black hole: formation and structure; Hubble's law; Structure of the universe: Open, closed and flat universe, Big Bang model, Basic ideas on Cosmic Microwave Background (CMB).

## **TUTORIAL: 1 Credit**

### **Total Lectures: 15**

Tutorial classes will be taken on the topics above based on the needs of the students.

### **RECOMMENDED BOOKS**

1. The physical universe – An introduction to astronomy, F. H. Shu, University of Science Books.
2. Astronomy Method - A physical approach to Astronomical Observation, Hale Bredt, Cambridge University Press.
3. Astrophysical Techniques, C R Kitchin, Institute of Physics Publishing Bristol and Philadelphia.
4. Astrophysics- Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill Pub.
5. Introduction to Astrophysics, H. L. Duorah and K. Duorah, Mani Manik Prakash.
6. An introduction to the theory of stellar structure and evolution, D. Prialnik, Cambridge University Press.
7. The structure of the universe, J. V. Narlikar, Oxford University Press.
8. Introduction to cosmology, B. Ryden, Cambridge University Press.

MINOR

### Programme Specific Outcome of Bachelor of Science - Physics Minor

| PSO No. | Name                                    | Outcome                                                                                                                                                                                                                                                                           |
|---------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PSO - 1 | Basic Knowledge                         | The learner will acquire knowledge regarding the fundamental principles of Physics through the study of Mechanics, Optics, Waves, Heat and Thermodynamics, Electricity and Magnetism, Modern Physics, Electronics.                                                                |
| PSO - 2 | Critical Thinking                       | The learner will be familiar with the state of the art of the appropriate level of technology for (a) experimental design and implementation, (b) analysis of experimental data.                                                                                                  |
| PSO - 3 | Communication Skill                     | The learner will learn effective communication skills to present their knowledge of physics from basic to advanced levels in the form of preparation of laboratory notebooks, project work, seminar presentations, poster presentations, wall magazines, models, and other modes. |
| PSO - 4 | Team Work                               | The learner will learn to work either independently or in a group during laboratory sessions, projects, and student seminar.                                                                                                                                                      |
| PSO - 5 | Competency for Competitive Examinations | The learner will be competent to face competitive examinations conducted by UPSC, APSC.                                                                                                                                                                                           |
| PSO - 6 | Ethical Thinking                        | The student will acquire a purposeful knowledge of scientific literature and ethical issues related to physics.                                                                                                                                                                   |

### Basic Syllabus Structure of Minor Course

| Semester | Course Code & Name                                             | Contents                                                                                                                                                                               |
|----------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1</b> | MATHEMATICAL PHYSICS - I & MECHANICS - I<br>PY-MN-1114         | Vectors and scalars<br>Vector differentiation Vector differential operator Vector Integration<br>Work energy principle Rigid body dynamics Gravitation<br>Special theory of relativity |
| <b>2</b> | MATHEMATICAL PHYSICS - II & PROPERTIES OF MATTER<br>PY-MN-2114 | Ordinary Differential Equation<br>Partial Differential Equation Elasticity<br>Surface Tension<br>Viscosity                                                                             |
| <b>3</b> | OPTICS<br>PY-MN-3214                                           | Geometrical Optics<br>Wave Optics                                                                                                                                                      |
| <b>4</b> | WAVES & APPLIED OPTICS<br>PY-MN-4214                           | Harmonic Motion<br>Wave Motion Sound Wave<br>Superposition of two harmonic waves<br>Ultrasonic Wave                                                                                    |
| <b>5</b> | ELECTRICITY AND MAGNETISM<br>PY-MN-5214                        | Electrostatics<br>Current Electricity Magnetostatics Electromagnetic Wave                                                                                                              |
| <b>6</b> | THERMAL PHYSICS<br>PY-MN-6214                                  | Heat<br>Thermodynamics Thermal Radiation Kinetic Theory of gases                                                                                                                       |
| <b>7</b> | MODERN PHYSICS – I<br>PY-MN-7314                               | Atomic Physics<br>Nuclear Physics<br>Quantum Physics                                                                                                                                   |

|   |                                   |                                                                                                                                  |
|---|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 8 | MODERN PHYSICS – II<br>PY-MN-8314 | Basics of Semiconductors<br>Two-terminal Devices<br>Basics of Transistors<br>Crystalline Solids<br>Physical Properties of Solids |
|---|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|

### Course Learning Outcome (CLO)

| Semester | Course Name & Code                                                   | Course Learning Outcome (CLO) |                                                                                                                                                                                                                                                                                                                  |
|----------|----------------------------------------------------------------------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | MATHEMATICAL PHYSICS – I<br>&<br>MECHANICS - I<br>PY-MN-1114         | CLO - 01                      | After completing the course a student will be able to understand vector and their applications in various fields.                                                                                                                                                                                                |
|          |                                                                      | CLO - 02                      | Further, a student will be able to understand and solve a real-life problem that needs an understanding of the laws of mechanics, gravitation, and relativity.                                                                                                                                                   |
| 2        | MATHEMATICAL PHYSICS - II<br>&<br>PROPERTIES OF MATTER<br>PY-MN-2114 | CLO - 01                      | After completing the course a student will be able to understand applications of differential equation in various fields. fields.                                                                                                                                                                                |
|          |                                                                      | CLO - 02                      | Further, a student will be able to understand and solve a real-life problem that needs an understanding of the elasticity, surface tension and viscosity.                                                                                                                                                        |
| 3        | OPTICS<br>PY-CE-3214                                                 | CLO - 01                      | After successful completion of the course, a learner will learn about formation of image due to a system of lenses, and defects of images of different types.                                                                                                                                                    |
|          |                                                                      | CLO - 02                      | Also, the learner will learn about detailed theory of wave like behaviour of light through the phenomena - interference, diffraction, and polarisation as well as associated phenomena - colour of thin film, Newton's ring etc.                                                                                 |
|          |                                                                      | CLO - 03                      | The learner will also learn about Laser and the propagation of light through fibre along with their practical applications.                                                                                                                                                                                      |
| 4        | WAVES & APPLIED OPTICS<br>PY-MN-4214                                 | CLO - 01                      | This course will acquaint the learner with the oscillatory motion of simple harmonic type and its classification under different physical conditions; phenomenon like resonance. They will learn about wave motion in an elastic medium and its mathematical analysis, superposition of waves, stationary waves. |
|          |                                                                      | CLO - 02                      | Also, they will learn about propagation of sound in an elastic medium, Newton's formula to determine the velocity of sound and Laplace correction. Fourier analysis of sound wave will also be learned in this course.                                                                                           |
|          |                                                                      | CLO - 03                      | This course will help in understanding musical notes and working of the musical instruments; necessary criteria for constructing an auditorium etc.                                                                                                                                                              |

|   |                                         |          |                                                                                                                                                                                                                                                                            |
|---|-----------------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   |                                         | CLO - 04 | After the course, the student will learn to handle practical instruments with laser, and fibre optics.                                                                                                                                                                     |
| 5 | ELECTRICITY AND MAGNETISM<br>PY-MN-5214 | CLO - 01 | One will learn the fundamental properties of charged particles and electric fields in this course.                                                                                                                                                                         |
|   |                                         | CLO - 02 | This course will give learners an understanding of the phenomena of electricity, magnetism, electromagnetic induction, and electrical circuits which are essential for higher studies in physics and also important for various engineering applications.                  |
|   |                                         | CLO - 03 | This course builds the basis for studying more advanced topics in electromagnetic theory                                                                                                                                                                                   |
|   |                                         |          |                                                                                                                                                                                                                                                                            |
| 6 | THERMAL PHYSICS<br>PY-MN-6214           | CLO - 01 | The basic laws of nature associated with heat and thermodynamics, the conversion of heat into work and vice-versa, principle of working of machine- carnot engine, concept of entropy, thermodynamic potentials, etc. Also, they will learn about kinetic theory of gases. |
|   |                                         | CLO - 02 | They will learn to apply the concept of kinetic theory of gases to explain the real life physical phenomena like thermal conductivity, diffusion of gases in a medium, phenomenon like brownian motion, etc.                                                               |
| 7 | MODERN PHYSICS – I<br>PY-MN-7314        | CLO - 01 | On successful completion of the course, the learner will learn about the structure of atom and its behaviour in electric and magnetic field.                                                                                                                               |
|   |                                         | CLO - 02 | The learner will learn the constituents of nucleus, binding energy and understand the concept of stability of nucleus and the cause of radioactivity.                                                                                                                      |
|   |                                         | CLO - 03 | Upon completion of this course, students will get receive a broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation which is one of the important equation for studying quantum mechanical systems will be learned.           |
|   |                                         | CLO - 04 | This knowledge will help them in future study and doing R&D jobs. The knowledge of nuclear physics will make them competent to pursue a career in radiological physics, nuclear power plant, etc.                                                                          |
| 8 | MODERN PHYSICS – II<br>PY-MN-8314       | CLO - 01 | On successful completion of the course, students will be able to understand the Semiconductor physics mainly p-n junction and its working in many devices such as rectifier, Zener diode, LED, etc. In addition, student will get introductory ideas about Transistor.     |
|   |                                         | CLO - 02 | This course provides a foundation for crystal structure of crystalline solids. On successful completion of this course students will be able to learn about the introductory concepts of conductivity, magnetism and superconductivity in solid systems.                   |

|  |  |          |                                                                                                                                                                   |
|--|--|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  | CLO - 03 | Upon completion of this course, students will get hands-on experience on working of various electronic devices and their industrial uses.                         |
|  |  | CLO - 04 | The learner will develop the skill to solve the experimental problems and analyze the experimental data collected from each experiment and interpret the results. |

## Mapping of Programme Outcome (PO) and Course Learning Outcome (CLO):

**Attributes:** Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

| Courses    | CLO     | Programme Outcome (SPO) |         |         |         |         |         |         |         |         |          |          |
|------------|---------|-------------------------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
|            |         | SPO - 1                 | SPO - 2 | SPO - 3 | SPO - 4 | SPO - 5 | SPO - 6 | SPO - 7 | SPO - 8 | SPO - 9 | SPO - 10 | SPO - 11 |
| PY-MN-1114 | CLO - 1 | 3                       | 1       | 1       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 2 | 3                       | 1       | 1       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
| PY-MN-2114 | CLO - 1 | 3                       | 1       | 1       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 2 | 3                       | 1       | 1       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
| PY-MN-3214 | CLO - 1 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 2 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 3 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
| PY-MN-4214 | CLO - 1 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 2 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 3 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
|            | CLO - 4 | 2                       | 2       | 2       | 1       | 2       | 1       | 1       | 1       | 1       | 2        | 2        |
| PY-MN-5214 | CLO - 1 | 1                       | 3       | 3       | 1       | 2       | 2       | 1       | 1       | 2       | 2        | 2        |
|            | CLO - 2 | 1                       | 3       | 3       | 1       | 2       | 2       | 1       | 1       | 2       | 2        | 2        |
|            | CLO - 3 | 1                       | 3       | 3       | 1       | 2       | 2       | 1       | 1       | 2       | 2        | 2        |
| PY-MN-6214 | CLO - 1 | 1                       | 3       | 3       | 1       | 2       | 2       | 1       | 1       | 2       | 2        | 2        |
|            | CLO - 2 | 1                       | 3       | 3       | 1       | 2       | 2       | 1       | 1       | 2       | 2        | 2        |
| PY-MN-7314 | CLO - 1 | 3                       | 2       | 2       | 2       | 2       | 2       | 2       | 1       | 1       | 2        | 1        |
|            | CLO - 2 | 2                       | 2       | 2       | 2       | 2       | 2       | 1       | 1       | 2       | 1        | 1        |
|            | CLO - 3 | 3                       | 2       | 2       | 2       | 2       | 2       | 2       | 1       | 1       | 2        | 1        |
|            | CLO - 4 | 3                       | 2       | 2       | 2       | 1       | 2       | 1       | 2       | 2       | 2        | 1        |
| PY-MN-8314 | CLO - 1 | 2                       | 2       | 2       | 2       | 2       | 2       | 1       | 1       | 1       | 1        | 1        |
|            | CLO - 2 | 3                       | 2       | 2       | 2       | 2       | 1       | 2       | 2       | 1       | 1        | 1        |
|            | CLO - 3 | 3                       | 2       | 2       | 2       | 2       | 2       | 2       | 1       | 2       | 2        | 1        |
|            | CLO - 4 | 3                       | 1       | 1       | 2       | 1       | 2       | 1       | 3       | 1       | 1        | 1        |

## Mapping of Programme Specific Outcome (PSO) and Course Learning Outcome (CLO)

**Attributes:** Co-relation Levels

“1” : Minimum Co-relation

“2” : Moderate Co-relation

“3” : Maximum Co-relation

“-” : No Co-relation

| Courses    | CLO     | PROGRAMME SPECIFIC OUTCOME |         |         |         |         |         |
|------------|---------|----------------------------|---------|---------|---------|---------|---------|
|            |         | PSO - 1                    | PSO - 2 | PSO - 3 | PSO - 4 | PSO - 5 | PSO - 6 |
| PY-MN-1114 | CLO – 1 | 3                          | 1       | 2       | 1       | 1       | 1       |
|            | CLO – 2 | 3                          | 1       | 2       | 1       | 1       | 1       |
| PY-MN-2114 | CLO – 1 | 3                          | 1       | 2       | 1       | 1       | 1       |
|            | CLO – 2 | 3                          | 1       | 2       | 1       | 1       | 1       |
| PY-MN-3214 | CLO – 1 | 2                          | 2       | 2       | 1       | 1       | 1       |
|            | CLO – 2 | 2                          | 2       | 2       | 1       | 1       | 1       |
|            | CLO – 3 | 2                          | 2       | 2       | 1       | 1       | 1       |
| PY-MN-4214 | CLO – 1 | 2                          | 2       | 2       | 1       | 1       | 1       |
|            | CLO – 2 | 2                          | 2       | 2       | 1       | 1       | 1       |
|            | CLO – 3 | 2                          | 2       | 2       | 1       | 1       | 1       |
|            | CLO – 4 | 2                          | 2       | 2       | 1       | 1       | 1       |
| PY-MN-5214 | CLO – 1 | 1                          | 3       | 2       | 1       | 2       | 1       |
|            | CLO – 2 | 1                          | 3       | 2       | 1       | 2       | 1       |
|            | CLO – 3 | 1                          | 3       |         | 1       | 2       | 1       |
| PY-MN-6214 | CLO – 1 | 1                          | 3       | 2       | 1       | 2       | 1       |
|            | CLO – 2 | 1                          | 3       | 2       | 1       | 2       | 1       |
| PY-MN-7314 | CLO - 1 | 3                          | 2       | 2       | 2       | 2       | 2       |
|            | CLO - 2 | 3                          | 2       | 2       | 2       | 2       | 2       |
|            | CLO - 3 | 3                          | 2       | 2       | 2       | 2       | 2       |
|            | CLO - 4 | 2                          | 2       | 2       | 2       | 2       | 2       |
| PY-MN-8314 | CLO - 1 | 3                          | 2       | 2       | 2       | 2       | 2       |
|            | CLO - 2 | 3                          | 2       | 2       | 2       | 1       | 2       |
|            | CLO - 3 | 2                          | 2       | 2       | 2       | 2       | 2       |
|            | CLO - 4 | 3                          | 2       | 2       | 2       | 2       | 1       |

**COURSE NAME: Mathematical Physics - I and Mechanics - I**

**COURSE CODE: PY- MN - 1114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

### **Course Objectives:**

*To impart advanced concepts and methods in Mathematics which include the Calculus of vector-valued functions.*

*To impart basic concepts of work-energy principle, rigid body dynamics, laws of gravitation, and a basic concept of relativity.*

### **Course Learning Outcome:**

**CLO-01:** *After completing the course a student will be able to understand vector and their applications in various fields.*

**CLO-02:** *Further, a student will be able to understand and solve a real-life problem that needs an understanding of the laws of mechanics, gravitation, and relativity.*

## **Mathematical Physics - I (Credit - 1; No. of lectures - 15)**

### **Unit I: Vector and scalars(Lectures 2)**

Introduction, dot and cross products including triple products, their physical significance

### **Unit II: Vector differentiation (Lectures 3)**

Ordinary derivative of vectors, continuity, and differentiability, the partial derivative of vectors, applications to problems in Physics.

### **Unit III: Vector differential operator(Lectures 5)**

Gradient, divergence, and curl - definitions and physical meaning, formulas involving  $\nabla$  and invariance

### **Unit IV: Vector Integration (Lectures 5)**

Ordinary integrals of vectors - line integral, surface integral and volume integral, Gauss's theorem, Stoke's theorem and Green's theorem (no rigorous proof is required)

## **Mechanics – I (Credit - 2; No. of lectures - 30)**

### **Unit V: Work energy principle (Lectures 8)**

Laws of motion - Concepts of work, energy, and power, Conservative forces - conservative force as a negative gradient of potential, Conservation of linear and angular momentum, motion of a rocket.

Centre of mass - motion of the centre of mass, collision problem in the centre of mass frame of reference and laboratory frame of reference

### **Unit VI: Rigid body dynamics (Lectures 9)**

Rotational motion - translation and rotational motion, torque, angular momentum. Moment of inertia - general theorem of the moment of inertia, moment of inertia calculation in particular cases - disk, cylinder, and sphere; flywheel, the kinetic energy of rotational motion.

### **Unit VII: Gravitation (Lectures 7)**

Newton's law of gravitation, Gravitational field - the intensity of the field, gravitational potential, and gravitational potential energy; gravitational field and potential due to a solid sphere and spherical shell. Motion under the central force field, two body problems, and reduced mass.

### **Unit VIII: Special theory of relativity (Lectures 6)**

Reference frame - inertial and non-inertial, Galilean Transformation, Galilean Invariance, Postulates of special theory of relativity, Lorentz Transformation equations - length contraction, time dilation and mass variation.

## **PRACTICAL**

### **Total Lectures: 30**

*A minimum of five experiments to be done.*

1. To measure the thickness of a piece of glass using a vernier calliper, screw gauge, and spherometer and compare their results.
2. To measure the diameter of a capillary tube using a traveling microscope.
3. To determine the height using a sextant.
4. To determine the Moment of Inertia of a Symmetrical body about an axis by the torsional oscillation method.
5. To determine the moment of inertia of a flywheel.
6. To find the angular acceleration and torque of a flywheel.
7. To determine the value of  $g$  using Bar Pendulum.
8. To determine the value of  $g$  using Kater's Pendulum
9. To determine the value of  $g$  using the motion of an oscillating spring.

### **BOOKS RECOMMENDED:**

1. Vector Analysis, Murray R. Spiegel (Schaum Series)
2. Mathematical Methods for Engineers and Scientists, K. T. Tang
3. Higher Engineering Mathematics, H. K. Das.
4. An Introduction to Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw Hill.
5. Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. Physics, Resnick, Halliday, and Walker 8/e. 2008, Wiley.
8. B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
9. A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

**COURSE NAME: Mathematical Physics - II and Properties of Matter**

**COURSE CODE: PY- MN - 2114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 45**

### **Course Objectives:**

*To impart advanced concepts and methods in Mathematics which include the Calculus of vector-valued functions.*

*To impart basic concepts of work-energy principle, rigid body dynamics, laws of gravitation, and a basic concept of relativity.*

### **Course Learning Outcome:**

**CLO-01:** *After completing the course a student will be able to understand application of differential equation in various fields.*

**CLO-02:** *Further, a student will be able to understand and solve a real-life problem that needs an understanding of elasticity, surface tension and viscosity.*

## **Mathematical Physics - II (Credit - 1, Lectures - 15)**

### **Unit I: Ordinary Differential Equation (Lectures 8)**

Order and degree of a differential equation, 1st order linear differential equation, 1st order and 2nd order homogenous differential equation. Radioactive decay, Newton's law of cooling, Free fall.

### **Unit II: Partial Differential Equation (Lectures 7)**

Solution of Partial differential equation using separation of variables, exact and inexact differentials. Laplace's equation in the cartesian coordinate system, Wave equation.

## **Properties of Matter (Credit - 2, Lectures - 30)**

### **Unit III: Elasticity (Lectures 10)**

Hooke's law, Elastic behaviour of solids, Different types of elasticity, Elastic constants, Relation among different elastic constants, Poisson's ratio, determination of Poisson's ratio, Twisting couple of a cylinder. Bending moment, depression of a cantilever.

### **Unit IV: Surface Tension (Lectures 10)**

Surface tension and surface energy, the Pressure difference across a liquid surface - drops and bubbles, Rise of liquid in a capillary tube - Jurin's law

### **Unit V: Viscosity (Lectures 10)**

The flow of liquid, streamline flow, continuity equation - Bernoulli's theorem and its applications, Viscosity, coefficient of viscosity, Reynold's number, Poiseuille's equation, Effect of temperature and pressure on the viscosity of fluids.

## PRACTICAL

**Total Lectures: 30**

*A minimum of five experiments are to be done.*

1. To determine the Young's Modulus of the material of a wire by Searle's apparatus.
2. To determine the Modulus of Rigidity of a Wire Static method.
3. To determine the spring constant and rigidity modulus from the motion of a spring.
4. To determine the surface tension of water by Jaeger's method.
5. To determine the coefficient of viscosity of water by capillary flow method (Poiseuille's method).
6. To determine the surface tension of a liquid by the capillary rise method and verify Jurin's law
7. To determine the coefficient of viscosity of glycerine or mustard oil by Stoke's method.

## BOOKS RECOMMENDED:

1. Mathematical Methods for Engineers and Scientists, K. T. Tang
2. Higher Engineering Mathematics, H. K. Das.
3. An Introduction to Mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw Hill.
4. Properties of Matter by D. S. Mathur, S. Chand, and Company.
5. B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
6. A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

**COURSE NAME: Optics**

**COURSE CODE: PY- MN - 3214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objectives:**

*To impart knowledge regarding image formation due to a system of lenses. To impart knowledge about wave like behaviour of light and related phenomena like interference, diffraction, and polarization. Principles of Laser, and principle of fibre optics will be discussed along with their applications.*

**Course Learning Outcome:**

**CLO – 01:** *After successful completion of the course, a learner will learn about formation of image due to a system of lenses, and defects of images of different types.*

**CLO – 02:** *Also, the learner will learn about detailed theory of wave like behaviour of light through the phenomena - interference, diffraction, and polarisation as well as associated phenomena - colour of thin film, Newton's ring etc.*

**CLO – 03:** *The learner will also learn about Laser and the propagation of light through fibre along with their practical applications.*

**Unit I - Geometrical Optics (20 lectures)**

Fermat's principle - its application to laws of reflection and refraction, Refraction of paraxial rays at a single spherical surface, thick lens, magnification of image, interrelation among lateral, longitudinal, and angular magnification, Lagrange's law, and Helmholtz equation.

Defects of image

Spherical aberration and its minimization, Qualitative idea about coma, astigmatism and distortion, Chromatic aberration.

**Unit II - Wave Optics (25 lectures)**

Interference

Concept of light wave and its equation, Stokes' law, interference due to Fresnel's biprism, interference by a plane parallel film, colour of thin film, Newton's rings.

Diffraction

Difference between Fresnel and Fraunhofer classes, diffraction at a straight edge and a circular aperture, Fraunhofer diffraction due to a single slit, grating (its reduction to double slit), Resolving power and Dispersive power (derivation not required).

Polarisation

Plane polarised light, polarisation on reflection, Brewster's law, double refraction, Nicol prism, rotation of plane of polarization by optically active substances, specific rotation, polarimeter.

## PRACTICAL

**Total Lectures: 30**

### List of Experiments

*Minimum number of experiments to be performed is six*

1. To determine the refractive index of a liquid by using plane mirror and convex lens.
2. To determine the focal length of two lenses and their combination by displacement method.
3. Familiarization with Schuster's focusing, determination of angle of prism.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine wavelength of sodium light using Newton's Rings.
8. To determine the thickness of a thin sheet/paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10. To determine dispersive power and resolving power of a plane diffraction grating.
11. To determine the specific rotation of sugar solution using a polarimeter.

### BOOKS RECOMMENDED:

1. B Ghosh and KG Mazumdar. "A Text Book on Light". In: Sreedhar Pub., Calcutta, (2003).
2. B.K. Mathur. Principles of Optics. Gopala Printing, 1964. URL: <https://books.google.co.in/books?id=h85ttwAACAAJ>.
3. P Chakrabarti. Geometrical & Physical Optics. New Central Book Agency, 2010.
4. A. Ghatak. Optics. McGraw-Hill Education, 2009. ISBN: 9780073380483. URL: <https://books.google.co.in/books?id=KTMHOQAACAAJ>.
5. Eugene Hecht. Optics. Pearson Education India, 2012.
6. CL Arora. B. Sc. Practical Physics. S. Chand Publishing, 2001.
7. S. Ghosh. A Textbook Of Advanced Practical Physics. New Central Book Agency (P) Limited, 2013. ISBN: 9788173812439. URL: [https://books.google.co.in/books?id=HrWR0uAe\\_sMC](https://books.google.co.in/books?id=HrWR0uAe_sMC).
8. D Chattopadhyay and PC Rakshit. An advanced course in practical physics. New Central Book Agency, 1990.

**COURSE NAME: Waves & Applied Optics**

**COURSE CODE: PY- MN - 4214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objectives:**

*The objective of the course is to acquaint the learner with the concept of oscillatory motion of simple harmonic type and its different characteristics. Also, a broad overview will be given about propagation of wave in an elastic medium and different aspects of sound wave. Also, Fourier analysis of sound wave will be done. Principles of Laser, and Fibre Optics will be discussed along with their applications.*

**Course Learning Outcome:**

**CLO – 01:** *This course will acquaint the learner with the oscillatory motion of simple harmonic type and its classification under different physical conditions; phenomenon like resonance. They will learn about wave motion in an elastic medium and its mathematical analysis, superposition of waves, stationary waves.*

**CLO – 02:** *Also, they will learn about propagation of sound in an elastic medium, Newton's formula to determine the velocity of sound and Laplace correction. Fourier analysis of sound wave will also be learned in this course.*

**CLO – 03:** *This course will help in understanding musical notes and working of the musical instruments; necessary criteria for constructing an auditorium etc.*

**CLO – 04:** *After the course, the student will learn to handle practical instruments with laser, and fibre optics.*

**Unit I - Harmonic Motion (8 lectures)**

Simple Harmonic motion, Composition of two simple harmonic oscillations at right angles, Lissajous figures. Free, damped, and forced oscillations, resonance, and sharpness of resonance.

**Unit II - Wave Motion (6 lectures)**

Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of Wave Equation. Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave, Water Waves - Ripple and Gravity Waves.

**Unit III - Sound Wave (8 lectures)**

Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal Waves in a Fluid in a Pipe, Newton's Formula for Velocity of Sound, Laplace's Correction, effect of temperature and pressure on velocity of sound in air, intensity level of sound and its unit (bel and decibel), Acoustics of auditorium, reverberation, Sabine's law.

**Unit IV - Superposition of Two Harmonic Waves (7 lectures)**

Standing (Stationary) Waves in a String - Fixed and Free Ends, Phase and Group Velocities, Changes

w.r.t Position and Time, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes.

#### **Unit V - Ultrasonic Wave (6 lectures)**

Ultrasonic waves – production of ultrasonic waves, application of ultrasonic waves, principle of SONAR system.

#### **Unit VI - Applied Optics (10 lectures)**

**Laser:** Laser and its characteristics, stimulated absorption, spontaneous and stimulated emission, population inversion, basic elements of laser, Ruby laser, He-Ne laser (principle only).

**Fibre Optics:** Optical fibres and their properties, Principle of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit.

#### **PRACTICAL**

##### **Total Lectures: 30**

##### **List of Experiments**

*Minimum number of experiments to be performed is six*

1. Study the motion of a spring in different medium (a) air and (b) water/kerosene oil. Calculate the value of  $g$  in both cases and compare the result.
2. Determine the frequency of an electric tuning fork by Melde's experiment and verify  $\lambda^2 - T$  law.
3. Study the Lissajous figure of two waves using a CRO and determine the value of unknown frequency of the wave.
4. Determine the velocity of sound wave in air at room temperature using a resonance tube at three different resonance positions.
5. Study the relation between frequency and length/tension of a given wire under constant tension using a sonometer and also plot a graph between frequency and length/tension.
6. Study the diffraction of light due to the propagation of an ultrasonic wave in a given liquid and calculate the speed of sound in the given liquid.
7. Determine the grating radial spacing of the CD and DVD by using either reflection or refraction method with a He-Ne or Solid State laser. Compare the experimental value with the theoretical one.
8. Find the width of the given wire using diffraction pattern obtained by a He-Ne or solid state laser and verify the result using a screw gauge.
9. Study the V-I characteristics of a light dependent resistor (LDR). Show the relation between resistance and distance of light source and calculate the dark resistance of the LDR.
10. Study the V-I characteristics of a photovoltaic cell and calculate the fill factor and efficiency of the cell.
11. Measure the numerical aperture and acceptance angle of an optical fibre.

##### **BOOKS RECOMMENDED:**

1. N.K. Bajaj. The Physics Of Waves And Oscillations. Tata Mcgraw-Hill, 1988. Isbn: 9780074516102. Url: <https://Books.Google.Co.In/Books?Id=Lw1hzweacaaj>.

2. M. Ghosh And D. Bhattacharya. A Textbook Of Oscillations, Waves And Acoustics. 5th. S. Chand Publications, 2007. Isbn: 9789385676154.
3. H.J. Pain. Physics Of Vibrations And Waves. John Wiley & Sons, Incorporated., 2005. Url: <https://Books.Google.Co.In/Books?Id=2zbn0aeacaaj>.
4. Anthony Philip French. Vibrations And Waves. Crc Press, 2017.
5. Francis A. Jenkins And Harvey E. White. Fundamentals Of Optics. Tata Mcgraw-Hill, 1981.
6. K.Thyagarajan And A.K.Ghatak. Lasers: Fundamentals & Applications. Tata Mcgraw Hill, 2010.
7. M.R. Shenoy Et Al. Fiber Optics Through Experiments. Mv Learning, 2015. Isbn: 9788130929835. Url: [https://Books.Google.Co.In/Books?Id=Z\\_Vzjweacaaj](https://Books.Google.Co.In/Books?Id=Z_Vzjweacaaj).
8. S.C. Gupta. Optoelectronic Devices And Systems. Phi Learning, 2005. Isbn: 9788120326941. Url: <https://Books.Google.Co.In/Books?Id=A7j9w8xbs88c>.
9. A. Lipson, S.G. Lipson, And H. Lipson. Optical Physics. Cambridge University Press, 2010. Isbn: 9781139492607. Url: <https://Books.Google.Co.In/Books?Id=Aow3o0dhyjyc>

**COURSE NAME: Electricity and Magnetism**

**COURSE CODE: PY- MN - 5214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objectives:**

*The objective of the course is to give the learners a broad overview of Electrostatic, Current Electricity, and Magnetostatics which are essentially required for the pursuance of Higher Studies or doing R & D job.*

Course Learning Outcome:

**CLO – 01:** *One will learn the fundamental properties of charged particles and electric fields in this course.*

**CLO – 02:** *This course will give learners an understanding of the phenomena of electricity, magnetism, electromagnetic induction, and electrical circuits which are essential for higher studies in physics and also important for various engineering applications.*

**CLO – 03:** *This course builds the basis for studying more advanced topics in electromagnetic theory*

**Unit I – Electrostatics (12 lectures)**

Gauss's theorem and its applications to determine field due to linear, plane and spherical charge distribution, potential due to dipole, derivation of field due to a dipole, Mutual potential energy of two dipoles.

Capacity of parallel plate capacitor, spherical and cylindrical capacitor, effect of dielectric on capacity of capacitor, mechanical force on charged conductor, energy stored in a charged capacitor.

Dielectrics, Electric polarisation of dielectrics, polarizability, Relation between D, E, & P, Gauss's law in dielectric. Electrostatic boundary conditions in dielectric medium.

**Unit II - Current Electricity (12 lectures)**

Electric current density, continuity equation, Ohm's law as  $J = \sigma E$ , Applications of Kirchhoff's law to solve electrical network problem.

Moving coil ballistic galvanometer its sensitivity and uses.

Electromagnetic induction: Self and mutual induction, coefficient of coupling, reciprocity theorem, self induction of a long solenoid, mutual induction of two solenoids.

Transient growth and decay of current in LR, CR and LCR circuits.

Alternating current: Generation of alternating current, current and potential across resistive, inductive and capacitive elements and their phase relationships, power factor, concept of rotating magnetic field. a.c. motor, transformer, reflected impedance in transformer.

**Unit III – Magnetostatics (15 lectures)**

Electric current as source of magnetic field, Equivalent magnetic dipole produced by a current flowing through a circular conductor, magnetic dipole moment, force and couples on dipole placed in a uniform

magnetic field, magnetic shell, potential due to magnetic shell, magnetic intensity, induction and intensity of magnetisation, magnetic susceptibility, permeability, hysteresis and hysteresis loss.

Dia, para and ferro magnetism, Atomic dipole moment, Langevin's Classical theory of para magnetism.

#### **Unit IV - Electromagnetic wave (6 lectures)**

Maxwell's equations, wave equation in free space from Maxwell's equations, velocity of electromagnetic waves in free space, Poynting vector.

#### **PRACTICAL**

##### **Total Lectures: 30**

##### **List of Experiments**

*Minimum number of experiments to be performed is six*

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

##### **BOOKS RECOMMENDED :**

1. D.J. Griffiths. Introduction to Electrodynamics. Cambridge University Press, 2017. ISBN: 9781108357142. URL: <https://books.google.co.in/books?id=Kh4xDwAAQBAJ>.
2. Vasudeva.D. N. Fundamentals of Magnetism and Electricity. S. Chand Limited, 2007. ISBN: 9788121909556. URL: <https://books.google.co.in/books?id=DbucEAAAQBAJ>.
3. D. Chattopadhyay. Electricity And Magnetism. New Central Book Agency (P) Limited, 2013. ISBN: 9788173812514. URL: <https://books.google.co.in/books?id=0WWmcgeF1XQC>.
4. Laud.B. B. Electromagnetics. Wiley Eastern, 1987. ISBN: 9780852264997. URL: <https://books.google.co.in/books?id=XtgFvbd9F2UC>

**COURSE NAME: Thermal Physics**

**COURSE CODE: PY- MN - 6214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

Course Objective:

*The objective of the course is to provide a broad overview of thermodynamics covering the fundamental principles involved - First and Second law of thermodynamics, conversion of heat into work and vice-versa, Carnot engine, concept of entropy, importance of thermodynamic potentials etc.*

*Also, the kinetic theory of gases will be covered with an objective to learn the molecular motion of gaseous particles, phenomena like thermal conduction, diffusion, brownian motion, etc.*

Course Learning Outcome :

**CLO – 01:** *The basic laws of nature associated with heat and thermodynamics, the conversion of heat into work and vice-versa, principle of working of machine - carnot engine, concept of entropy, thermodynamic potentials, etc. Also, they will learn about kinetic theory of gases.*

**CLO – 02:** *They will learn to apply the concept of kinetic theory of gases to explain the real life physical phenomena like thermal conductivity, diffusion of gases in a medium, phenomenon like brownian motion, etc.*

**Unit I – Heat (15 lectures)**

Platinum resistance thermometer and thermocouple thermometer.

The equation of state of real gases, Van-der-Waals' equation of state, reduced equation of state, critical constants. Zeroth law of thermodynamics and concept of temperature.

Joule-Thomson effect, liquefaction of gases by Joule-Thomson effect.

Phase, first order phase transitions, Clausius–Clayperon equation, Gibbs' phase rule, triple point.

**Unit II – Thermodynamics (10 lectures)**

Heat and work and their equivalence, First law of thermodynamics and concept of internal energy, Applications of first law of thermodynamics.

Inadequacy of first law of thermodynamics, Second law of thermodynamics, reversible and irreversible processes, isothermal and adiabatic processes, work done by perfect gas under isothermal and adiabatic expansion, Carnot engine and Carnot cycle, Thermodynamic scale of temperature.

Entropy, change of entropy in reversible and irreversible processes, Clausius inequality relation. Maxwell's thermodynamic relations and their applications.

**Unit III - Thermal radiation (13 lectures)**

Kirchhoff's law and its applications, relation between radiation pressure and energy density, Black body radiation, expressions of Stefan-Boltzmann law, Wien's displacement law, Rayleigh-Jean's law and Planck's law of black body radiation.

#### **Unit IV - Kinetic theory of gases (7 lectures)**

Kinetic theory of gases, expression of Maxwell's law of velocity distribution (deduction not necessary), degree of freedom, law of equipartition of energy, mean free path, Brownian motion.

#### **PRACTICAL**

**Total Lectures: 30**

##### **List of Experiments**

*Minimum number of experiments to be performed is four*

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance using Platinum Resistance Thermometer.
6. To determine the boiling point of a given liquid with the help of a Platinum Resistance thermometer.
7. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.
8. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

##### **BOOKS RECOMMENDED:**

1. P.K. Chakrabarti. Theory and Experiments on Thermal Physics. New Central Book Agency (P) Limited, 2013. ISBN: 9788173815041.  
URL: <https://books.google.co.in/books?id=JCNXhdvWCGkC>.
2. J.P. Agarwal and S. Prakash. Thermodynamics and Statistical Physics. Pragati Prakashan, 1993.  
URL: <https://books.google.co.in/books?id=6UCcGwAACAAJ>.
3. S.C. Garg, R.M. Bansal, and C.K. Ghosh. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics. McGraw Hill Education (India) Private Limited, 2013. ISBN: 9781259097614. URL: <https://books.google.co.in/books?id=VAbvjgEACAAJ>.
4. F.W. Sears and G.L. Salinger. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics. Addison-Wesley principles of physics series. Addison-Wesley Publishing Company, 1975. ISBN: 978020106894  
URL: <https://books.google.co.in/books?id=3gRRAAAAMAAJ>.

## **Course Title: Modern Physics-I**

**Course Code: PY-MN-7314**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

### **Course Objective:**

*The objective of the course is to provide broad overview of atomic structure and its behavior in electric and magnetic field. In this course, a broad overview of the constituents of nucleus, and its stability will be given. The phenomenon of radioactivity will also be covered. In addition, the introductory concept on elementary particles is also covered. The other objective of the course is to impart broad overview of the history of quantum mechanics and its gradual development.*

### **Course Learning Outcome:**

**CLO-01:** On successful completion of the course, the learner will learn about the structure of atom and its behaviour in electric and magnetic field.

**CLO-02:** The learner will learn the constituents of nucleus, binding energy and understand the concept of stability of nucleus and the cause of radioactivity.

**CLO-03:** Upon completion of this course, students will get receive a broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation which is one of the important equation for studying quantum mechanical systems will be learned.

**CLO-04:** This knowledge will help them in future study and doing R&D jobs. The knowledge of nuclear physics will make them competent to pursue a career in radiological physics, nuclear power plant, etc.

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### **THEORY: 3 Credits**

#### **Total Lectures: 45**

#### **Unit I: Atomic Physics**

**(Lectures 10)**

- Discovery of Charged Particles,  $e/m$  of the electron, Positive Ray Analysis: Thompson's Parabola method, X-ray Diffraction, Bragg's Law, Bohr's Atomic Model, Critical Potentials, X-Ray spectra-continuous and characteristic spectra, Mosley's Law.
- Pauli exclusion principle: spectral terms from two equivalent electrons, Vector model for three or more valence electrons and spectral terms, branching rule, Landé interval rule, LS and j-j coupling schemes, energy levels, selection rules, spectra of oxygen, nitrogen and manganese atoms; Franck and Hertz's Experiment, Zeeman effect, Paschen-Back effect, Stark effect in hydrogen, hyperfine structure, determination of nuclear spin and nuclear g factors, Breadth of spectrum lines: natural broadening, Doppler broadening, collision broadening, and Stark broadening.

#### **Unit II: Nuclear Physics**

**(Lectures 20)**

- General properties of atomic nuclei and its stability, Constituents of nucleus and their Intrinsic properties-quantitative facts about mass, radii, charge density, matter density, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

- Binding energy, the variation of binding energy per nucleon against mass number, the main features of B.E/A vs. mass number curve, mass defect and packing fraction, Nuclear stability, Nuclear force and its characteristics, Yukawa's mesonfield theory.
- Radioactive Decay, decay rate, secular and transient equilibrium.
- Alpha decay- range, energy, Geiger-Nuttall law, alpha disintegration energy, Spectrum of alpha particles.
- Beta decay- condition of spontaneous beta decay, beta particle spectrum, K-electron capture.
- Gamma decay- origin and energy spectrum, interaction of gamma radiation with matter.
- Classification of elementary particles and their quantum numbers, Types of particles and its families, Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin.

### Unit III: Quantum Physics

(Lectures 15)

- Origin of Quantum Theory - Inadequacy of classical physics, Planck's quantum hypothesis, Photoelectric effect, Compton effect, Wave-particle duality-de-Broglie hypothesis and genesis of quantum mechanics, Verification of matter wave- Davisson-Germer's experiment, G. P. Thomson's electron diffraction experiment (qualitative idea only), Heisenberg's uncertainty principle and complementarity principle of Neil Bohr, limitations on experiment.
- Development of the wave equation, time dependent Schrödinger's equation, Statistical interpretation wave function, probability current density, expectation value and operator, Ehrenfest's theorem, General solution of time dependent Schrödinger's equation for time independent potential. Schrödinger's equation in momentum space.

### TUTORIAL: 1 Credit

### Total Lectures: 15

Tutorial classes will be taken on the topics above based on the needs of the students.

### RECOMMENDED BOOKS

1. Beiser. Concepts of Modern Physics. McGraw-Hill higher education. McGraw-Hill, 2003.
2. J. B. Rajam. Atomic Physics. S. Chand & Company Pvt. Limited, 1974.
3. S. N. Ghoshal. Atomic Physics. S. Chand Limited, 2007.
4. S. B. Patel. Nuclear Physics: An Introduction. Wiley, 1991.
5. Krane. Kenneth. S. Introductory Nuclear Physics. Wiley India, 2008.
6. S. N. Ghoshal. Nuclear Physics. S. Chand Limited, 1997.
7. V. K. Mittal, R. C. Verma, and S. C. Gupta. Introduction to Nuclear and Particle Physics, Fourth Edition. PHI Learning Pvt. Ltd., 2018.
8. A. B. Gupta. Modern Atomic and Nuclear Physics. New Age International, 2009.
9. Nouredine Zettili. Quantum mechanics: concepts and applications. John Wiley & Sons, 2009.
10. David J Griffiths and Darrell F Schroeter. Introduction to quantum mechanics. Cambridge university press, 2018.
11. A. K. Ghatak and S. Lokanathan. Quantum Mechanics: Theory and Applications. Macmillan Publishers India Limited, 2004.

**Course Title: Modern Physics-II**  
**Course Code: PY-MN-8314**  
**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**Course Objective:**

*Here, the objective is to give learners a broad overview of solid materials with different aspects like structural, magnetic and superconducting properties as well as the forces that bind them together. An attempt is taken to make the learner aware of semiconductor physics and its applications. In addition, to introduce students to analog electronics with hands-on practice on implementing some of these in hardware.*

**Course Learning Outcome:**

**CLO-01:** On successful completion of the course, students will be able to understand the Semiconductor physics mainly p-n junction and its working in many devices such as rectifier, Zener diode, LED, etc. In addition, student will get introductory ideas about Transistor.

**CLO-02:** This course provides a foundation for crystal structure of crystalline solids. On successful completion of this course students will be able to learn about the introductory concepts of conductivity, magnetism and superconductivity in solid systems.

**CLO-03:** Upon completion of this course, students will get hands-on experience on working of various electronic devices and their industrial uses.

**CLO-04:** The learner will develop the skill to solve the experimental problems and analyze the experimental data collected from each experiment and interpret the results.

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**THEORY: 3 Credits**

**Total Lectures: 45**

**Unit-I: Basics of Semiconductors**

**(Lectures 09)** Concept of Energy-

Band in solids, Classifications of conductors, insulators and semiconductors, Intrinsic and extrinsic semiconductors and their corresponding energy-level diagram, P-N junction diode, Concept of drift and diffusion motion, Formation of depletion region in P-N junction diode, Current flow mechanism in forward and reverse biased conditions, Diode current equation, Static and dynamic resistances.

**Unit II: Two-terminal Devices**

**(Lectures 08)** Diode as

rectifier: Half-wave rectifiers, Centre-tapped full-wave rectifiers, Calculation of ripple factor and rectification efficiency, Clipper and clamper circuits using diode, Basic Principle and I-V Characteristics of (i) Zener diode, (ii) LED, and (iii) Solar cell.

**Unit III: Basics of Transistors**

**(Lectures 05)** n-p-n and

p-n-p Transistors, Characteristics of CB, CE and CC Configurations, Current gains  $\alpha$  and  $\beta$ , Relations between  $\alpha$  and  $\beta$ , Transistor as an amplifier.

**Unit IV: Crystalline Solids**

**(Lectures 06)**

Fundamentals of crystal structure, Amorphous and crystalline solids, Unit Cell, Primitive and non-primitive cells, Types of lattices: SC, FCC, BCC, Miller indices, Inter-planar distance.

## Unit V: Physical Properties of Solids

(Lectures 17)

- Conductivity: Conductivity of semiconductor, mobility, Measurement of conductivity by four-probe method, Band gap energy of semiconductor, Hall effect and Hall coefficient.
- Magnetism: Origin of magnetism in materials, Classification of magnetic materials: dia, para, and ferromagnetic materials. Weiss's Theory of Ferromagnetism, Curie-Weiss law, Ferromagnetic domains, Magnetic hysteresis curve and Energy Loss, Soft and hard magnetic materials.
- Superconductivity: Basic properties of superconductors: Critical temperature, critical magnetic field, Meissner effect, Type I and type II Superconductors, Qualitative idea on BCS theory.

## PRACTICAL: 1 Credit

**Total Lectures: 30**

### List of Experiments

*Minimum number of experiments to be performed is six.*

1. To study the V-I characteristics of a P-N junction diode in forward bias condition and determine the static and dynamic resistances.
2. To design a half wave rectifier circuit and calculate the ripple factor.
3. To design a bridge full wave rectifier and calculate the ripple factor.
4. To realize Clipper circuit using diode. Understanding the waveform change of diode clipping circuit when the bias is applied.
5. To realize Clamper circuit using diode. Understanding the waveform change of diode clamping circuit when the bias is applied.
6. To study the V-I characteristics of a given light emitting diode in forward bias condition and calculate the wavelength of the light emitted by the diode.
7. To study the V-I characteristics of a Zener diode in reverse biased condition and estimate the break down voltage of the Zener diode.
8. To study of V-I characteristics of a solar cell and find the maximum power point and fill factor.
9. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
10. To study a powder X-Ray diffraction data and to determine the lattice parameters, crystalline size, and inter planner distance. (*XRD data needs to be arranged by the Department*)
11. To measure the susceptibility of a paramagnetic solution by using Quinck's Tube Method.
12. To measure the Magnetic susceptibility of Solids by using Guoy method.
13. To draw the B-H curve of Fe using Solenoid and determine the energy loss from the Hysteresis curve.
14. To determine the coercively, retentively, and saturation magnetization of a given ferromagnetic specimen using B-H loop curve.
15. To measure the resistivity of a semiconductor with temperature by four-probe method and to determine its band gap energy.
16. To determine the Hall coefficient and carrier concentration of a semiconductor sample.

### RECOMMENDED BOOKS

1. S. M. Sze. Semiconductor Devices: Physics and Technology, 2nd Ed. Wiley India Pvt. Limited, 2008.
2. Electronics Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, 17th Ed,

2023, New Age International Publishers.

3. J. Millman. Integrated Electronics: Analog and Digital Circuits and Systems. Mcgraw-Hill Education (India) Pvt Limited, 2010.
4. B. G. Streetman and S. Banerjee. Solid State Electronic Devices. Pearson, 2015.
5. C. Kittel, Introduction to Solid State Physics. Wiley, 2018.
6. A. J. Dekker. Solid State Physics. Prentice-Hall technical books. Prentice-Hall, 1965.
7. S. O. Pillai. Modern Physics and Solid State Physics (Problems and Solutions). New Age International (P) Limited, 2008.
8. N. W. Ashcroft and N. D. Mermin. Solid State Physics. HRW international editions. Holt, Rinehart and Winston, 1976.

# SKILL ENHANCEMENT COURSE (SEC)

### Programme Specific Outcome of Bachelor of Science - Skill Enhancement Course

| PSO No. | Name                                            | Outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PSO - 1 | Basic Knowledge                                 | The learner will be familiar with computers and its associated softwares that are used in any digital environment. They will also learn the skill of computer coding with the help of Python Programming Language. Computer Algebra System (CAS) which is used in many scientific computation will be learned with the help Mathematica software. Further, they will learn about L <sup>A</sup> T <sub>E</sub> X, a scientific type setting system used for technical writing. |
| PSO - 2 | Skill Enhancement through ICT and Employability | Familiarity with computer and knowledge of Python and Mathematica will help learners to become suitable for many diverse scientific jobs in the field of data science, deep learning, artificial intelligence as well as core fields of science disciplines and also, its allied fields.                                                                                                                                                                                       |
| PSO - 3 | Communication Skill                             | The knowledge of L <sup>A</sup> T <sub>E</sub> X will make the learner competent for scientific communication. The learner will learn effective communication skills to present their knowledge through seminar, group discussion, etc.                                                                                                                                                                                                                                        |
| PSO - 4 | Team Work                                       | The learner will learn to work either independently or in a group during laboratory sessions, projects, and student seminar.                                                                                                                                                                                                                                                                                                                                                   |
| PSO - 5 | Ethical Thinking                                | The student will acquire a purposeful knowledge of scientific literature and ethical issues related to physics.                                                                                                                                                                                                                                                                                                                                                                |

### Basic Syllabus Structure of SEC

| Semester | Course Name & Code                                                   | Contents                                                         |
|----------|----------------------------------------------------------------------|------------------------------------------------------------------|
| 1        | Basic Computer Knowledge<br>PY-SE-1113                               | Knowing Computer                                                 |
|          |                                                                      | Operating Computer using GUI-Based Operating System              |
|          |                                                                      | Understanding Word Processing                                    |
|          |                                                                      | Understanding Spreadsheet                                        |
|          |                                                                      | Understanding Presentation Software                              |
|          |                                                                      | Introduction to Internet, WWW, and Web Browsers                  |
|          |                                                                      | Communications and Collaboration Lectures                        |
| 2        | Programming Skill with Python<br>PY-SE-2113                          | Introduction to Scientific Programming Algorithms and Flowcharts |
|          |                                                                      | Basics of Scientific Programming                                 |
|          |                                                                      | NumPy Fundamentals                                               |
|          |                                                                      | Visualization with Matplotlib                                    |
| 3        | Computer Algebra System and Scientific Word Processing<br>PY-SE-3213 | Introduction to CAS and Applications                             |
|          |                                                                      | Getting started with L <sup>A</sup> T <sub>E</sub> X             |
|          |                                                                      | Mathematical Typesetting with L <sup>A</sup> T <sub>E</sub> X    |

## Course Learning Outcome - Skill Enhancement Course (SEC)

| Semester | Course Name & Code                                                         | Course Learning Outcome (CLO) |                                                                                                                                                                                              |
|----------|----------------------------------------------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | Basic Computer Knowledge<br>PY-SE-1113                                     | CLO - 01                      | The learner will be able to use the computer for basic purposes like preparing his letters, notes, presentation, etc., viewing information on the Internet (the web), and sending mail, etc. |
|          |                                                                            | CLO - 02                      | This allows a student to be also part of a computer user list by making them digitally literate.                                                                                             |
|          |                                                                            | CLO - 03                      | This would also aid the PC penetration program.                                                                                                                                              |
|          |                                                                            | CLO - 04                      | This helps them to maintain their small account using the computers and enjoy the world of Information Technology.                                                                           |
| 2        | Programming Skills with Python<br>PY-SE-2113                               | CLO - 01                      | After completing the course a student will be able to do coding.                                                                                                                             |
|          |                                                                            | CLO - 02                      | It will help solving any real life problem.                                                                                                                                                  |
|          |                                                                            | CLO - 03                      | Python is a powerful programming language that offers exciting career opportunity in a wide range of industry.                                                                               |
| 3        | Computer Algebra System<br>and<br>Scientific Word Processing<br>PY-SE-3213 | CLO - 01                      | Use CAS as a calculator, for plotting functions and various applications.                                                                                                                    |
|          |                                                                            | CLO - 02                      | The learner will be able to write a scientific report using L <sup>A</sup> T <sub>E</sub> X software and presenting their work with the help of L <sup>A</sup> T <sub>E</sub> X Beamer       |
|          |                                                                            | CLO - 03                      | This knowledge will help them a lot in their future endeavour.                                                                                                                               |

### Mapping of Course Learning Outcome and Programme Outcome

| Courses    | CLO   | PROGRAMME OUTCOME |       |       |       |       |       |       |       |       |        |        |
|------------|-------|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
|            |       | SPO-1             | SPO-2 | SPO-3 | SPO-4 | SPO-5 | SPO-6 | SPO-7 | SPO-8 | SPO-9 | SPO-10 | SPO-11 |
| PY-SE-1113 | CLO 1 | 3                 | 1     | 2     | 3     | 2     | 2     | 1     | 1     | 3     | 2      | 2      |
|            | CLO 2 | 3                 | 1     | 2     | 3     | 2     | 2     | 1     | 1     | 3     | 2      | 2      |
|            | CLO 3 | 3                 | 1     | 2     | 3     | 2     | 2     | 1     | 1     | 3     | 2      | 2      |
|            | CLO 4 | 3                 | 1     | 2     | 3     | 2     | 2     | 1     | 1     | 3     | 2      | 2      |
| PY-SE-2113 | CLO 1 | 2                 | 2     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 2      | 2      |
|            | CLO 2 | 2                 | 2     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 2      | 2      |
|            | CLO 3 | 2                 | 2     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 2      | 2      |
| PY-SE-3213 | CLO 1 | 1                 | 3     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 3      | 2      |
|            | CLO 2 | 1                 | 3     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 3      | 2      |
|            | CLO 3 | 1                 | 3     | 2     | 3     | 2     | 3     | 1     | 1     | 3     | 3      | 2      |

### Mapping of Course Learning Outcome and Programme Specific Outcome

| Courses    | CLO   | Programme Specific Outcome (PSO) |         |         |         |         |
|------------|-------|----------------------------------|---------|---------|---------|---------|
|            |       | PSO - 1                          | PSO - 2 | PSO - 3 | PSO - 4 | PSO - 5 |
| PY-SE-1113 | CLO 1 | 3                                | 1       | 1       | 2       | 2       |
|            | CLO 2 | 3                                | 1       | 1       | 2       | 2       |
|            | CLO 3 | 3                                | 1       | 1       | 2       | 2       |
|            | CLO 4 | 3                                | 1       | 1       | 2       | 2       |
| PY-SE-2113 | CLO 1 | 2                                | 2       | 1       | 2       | 2       |
|            | CLO 2 | 2                                | 2       | 1       | 2       | 2       |
|            | CLO 3 | 2                                | 2       | 1       | 2       | 2       |
| PY-SE-3213 | CLO 1 | 1                                | 3       | 1       | 2       | 2       |
|            | CLO 2 | 1                                | 3       | 1       | 2       | 2       |
|            | CLO 3 | 1                                | 3       | 1       | 2       | 2       |

**COURSE NAME: Basic Computer Knowledge**

**COURSE CODE: PY- SE - 1113**

**Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 30**

Course Objective:

*The objective of the course is imparting a basic level of knowledge about computer and its related software in digital environment.*

**Course Learning Outcome:**

**CLO – 01 :** *The learner will be able to use the computer for basic purposes like preparing his letters, notes, presentation, etc., viewing information on the Internet (the web), and sending mail, etc.*

**CLO – 02 :** *This allows a student to be also part of a computer user list by making them digitally literate.*

**CLO – 03 :** *This would also aid the PC penetration program.*

**CLO – 04 :** *This helps them to maintain their small account using the computers and enjoy the world of Information Technology.*

### **Unit I: Knowing Computer (Lectures 2)**

What is a Computer, Basic Applications of a Computer; Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Concept of Computing, Data, and Information; Applications of IECT; Connecting keyboard, mouse, monitor and printer to CPU and checking power supply.

### **Unit II: Operating Computer using GUI-Based Operating System (Lecture 4)**

What is an Operating System; Basics of Popular Operating Systems; The User Interface, Using Mouse; Using right Button of the Mouse and Moving Icons on the screen, Use of Common Icons, Status Bar, Using Menu and Menu-selection, Running an Application, Viewing of File, Folders, and Directories, Creating and Renaming of files and folders, Opening and closing of different Windows; Using help; Creating Short cuts, Basics of O.S Setup; Common utilities.

### **Unit III: Understanding Word Processing (Lectures 6)**

Word Processing Basics; Opening and Closing of documents; Text creation and Manipulation; Formatting of text; Table handling; Spell check, language setting, and thesaurus; Printing of word document.

### **Unit IV: Understanding Spreadsheet (Lectures 6)**

Basics of Spreadsheet; Manipulation of cells; Formulas and Functions; Editing of Spread Sheet, the printing of Spread Sheet.

### **Unit V: Understanding Presentation Software (Lectures 6)**

Basics of presentation software; Creating Presentation; Preparation and Presentation of Slides; Slide Show; Taking printouts of presentation/handouts.

## **Unit VI: Introduction to Internet, WWW, and Web Browsers(Lectures 4)**

Basic of Computer networks; LAN, WAN; Concept of the Internet; Applications of the Internet; connecting to the Internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting, World Wide Web; Web Browsing software, Search Engines; Understanding URL; Domain name; IP Address; Using e-governance website.

## **Unit VII: Communications and Collaboration Lectures (Lecture 2)**

Basics of electronic mail; Getting an email account; Sending and receiving emails; Accessing sent emails; Using Emails; Document collaboration; Instant Messaging.

## **PRACTICAL**

### **Total Lectures: 30**

1. Do the following tasks specific to Windows Operating System
  - a. Creating a new folder, copying/pasting files.
  - b. Creating a new file.
  - c. Deleting a folder/file.
2. To check the hardware present in the computer, note down the specifications of the PC.
  - a. What is the operating system being used?
  - b. What service pack is installed?
  - c. What is the CPU name?
  - d. What is the clock speed of the computer's CPU?
3. Take an unformatted document and do all the formatting exercises as discussed in the theory class.
4. Create a spreadsheet and explore all the aspects discussed in the theory class.
5. Create a PowerPoint presentation on any topic and explore all the aspects as discussed in the theory class.
6. Choose an unknown topic and collect as much information as possible with the help of a search engine and record them appropriately.
7. Create a mail account and share documents as attached files.

## **BOOKS RECOMMENDED**

1. Operating System Principle by Galvin.
2. Data Communication Networks by Udit Agarwal.
3. A-Z MS/Excel by Ms. Rinkoo Jain.
4. Exploring ms/Office by Kevin Wilson.

**COURSE NAME: Programming Skills with Python**

**COURSE CODE: PY-SE-2113**

**Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 30**

### **Course Objectives:**

*The course is designed to provide Basic knowledge of Python. It will help one to learn how to design and program Python applications.*

### **Course Learning Outcome:**

**CLO – 1:** *After completing the course a student will acquire programming capability and will be able to solve a real-life problem.*

**CLO – 02 :** *It will help solving any real life problem.*

**CLO – 03 :** *Python is a powerful programming language that offers exciting career opportunity in a wide range of industry.*

### **Unit I: Introduction to Scientific Programming (Lectures 6)**

Algorithm: Definition, properties, and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of  $\sin(x)$  as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

### **Unit II: Basics of Scientific Programming (Lectures 16)**

**Variables and Formatting:** Introduction to HLL, Concepts of a Compiler. Character Set, Constants and their types, Variables and their types.

**Operators:** Arithmetic, Relational, Logical, and Assignment Operators.

**Expressions:** Arithmetic, Relational, Logical, Character, and Assignment Expressions. I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of a Program, Format of writing Program and concept of coding, Initialization, and Replacement Logic. Examples from physics problems.

**Control Statements and Functions:** Logical statements - IF, IF-ELSE block, Looping Statements - WHILE, FOR loop, Functions, open a file, writing in a file, reading from a file.

### **Unit III: Visualization (Lectures 8)**

Introduction to graphical analysis, the importance of visualization of computational data, simple plots, plotting data from a file, saving and exporting, multiple data sets per file, curve fitting – straight line, polynomials, user-defined function.

## PRACTICAL

### Total Lectures: 30

1. The height of a satellite above the earth should be

$$h = \left( \frac{GM_E T^2}{4\pi^2} \right)^{1/3} - R_E$$

where,  $G = 6.673 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$  is the universal gravitational constant.  $M_E = 5.98 \times 10^{24} \text{ kg}$ , mass of the earth,  $R_E = 6.37 \times 10^6 \text{ m}$ , radius of the earth

A geosynchronous orbit (GEO) is a prograde, low inclination orbit about Earth having a period of 23 hours 56 minutes 4 seconds. A spacecraft in geosynchronous orbit appears to remain above Earth at a constant longitude, although it may seem to wander north and south. Estimate the height of a Geosynchronous satellite.

2. To find a set of prime numbers between two given numbers.
3. Sum the series

$$\sum_{k=1}^{100} \frac{1}{k}$$

4. The Fibonacci numbers are the sequence of integers in which each is the sum of the previous two, with the first two numbers being 1, 1. Thus the first few members of the sequence are 1, 1, 2, 3, 5, 8, 13, 21.  
Calculate Fibonacci numbers up to 100.

5. Write a program for calculating the wavelengths of emission lines in the spectrum of the hydrogen atom, based on the Rydberg formula

$$\frac{1}{\lambda} = R \left( \frac{1}{m^2} - \frac{1}{n^2} \right)$$

The value of  $R = 1.097 \times 10^{-2} \text{ m}^{-1}$

6. The coordinate of a point in the cartesian coordinate system is given by  $(x, y)$  and that in the polar coordinate system is given by  $(r, \theta)$ . Write a user-defined function to transform coordinates from one system to another.
7. Make a plot of the curve which is defined by

$$x = 2 \cos \theta + \cos 2\theta; \quad y = 2 \sin \theta - \sin 2\theta$$

where  $0 \leq \theta \leq 2\pi$ . Take a set of values of  $\theta$  between 0 and  $2\pi$ , calculate  $x$  and  $y$  for each from the equations above, and then, plot  $y$  as a function  $x$ .

### BOOKS RECOMMENDED

1. Computational Physics, by Mark Newman.
2. Computational Physics: Problem Solving with Python, by Manuel J. Páez , Rubin H. Landau , Cristian C. Bordeianu.
3. Python Programming: An Introduction to Computer Science by John Zelle, Franklin, Beedle & Associates INC.

**COURSE NAME: Computer Algebra System and Scientific Word Processing**

**COURSE CODE: PY-SE-3213**

**Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)**

## **THEORY**

**Total Lectures: 30**

### **Course Objectives:**

*This course aims at familiarizing students with the usage of computer algebra systems using Mathematica. The basic emphasis is on plotting using CAS.*

Course Learning Outcome:

**CLO – 01:** *Use CAS as a calculator, for plotting functions and various applications.*

**CLO – 02:** *The learner will be able to write a scientific report using L<sup>A</sup>T<sub>E</sub>X software and presenting their work with the help of L<sup>A</sup>T<sub>E</sub>X Beamer.*

**CLO – 03:** *This knowledge will help them a lot in their future endeavour.*

### **Unit - I Introduction to CAS and Applications (15 lectures)**

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and Contour Plot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Factoring and expanding polynomials, Finding roots of a polynomial with Solve and NSolve, Solving system of equations.

Computing limits, Derivative and its visualization, Differential equations, Integral - definite and improper integrals, Numerical Integration.

Matrices - eigenvalues and eigenvectors.

### **Unit - II Getting started with L<sup>A</sup>T<sub>E</sub>X (15 lectures)**

Document Classes - article, report, book and beamer.

Page Layout - Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, equation/Figure References, Generating table of contents, bibliography and citation, Making an index and glossary.

List structures - Itemize, enumerate, description etc.

Representation of mathematical equations - Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surface-volume integrals with and without limits, closed line integral, surface integrals etc.

Customization of fonts - Bold fonts, emphasize, Changing sizes - Large, larger, Huge, tiny, etc. Writing tables - Creating tables with different alignments, placement of horizontal, vertical lines. Figures - Changing and placing the figures, alignments.

Packages - amsmath, amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. (simple ideas about their relevance in the context of a document).

## **PRACTICAL**

### **Total Lectures: 30**

Suitable Examples may be drawn to exemplify the content in theory section.

## **BOOKS RECOMMENDED**

1. B.F. Torrence and E.A. Torrence. The Student's Introduction to MATHEMATICA ®: A Handbook for Precalculus, Calculus, and Linear Algebra. Cambridge University Press, 2009. ISBN: 9781139473736. URL: <https://books.google.co.in/books?id=F8VhFRhZw-MC>.
2. L. Lamport. LATEX: A Document Preparation System : User's Guide and Reference Manual. Addison-Wesley series on Tools and Techniques for Computer Typesetting p. 2. Addison-Wesley, 1994. ISBN: 9780201529838.  
URL: <https://books.google.co.in/books?id=khVUAAAAMAAJ>

# INTER-DISCIPLINARY COURSE (IDC)

### Programme Specific Outcome of Bachelor of Science - IDC (Physics forAll)

| PSO No. | Name                                    | Outcome                                                                                                                                                                                                                                             |
|---------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PSO - 1 | Basic Knowledge                         | The learner will acquire knowledge about the contribution of great scientists who has enriched our knowledge about science particularly Physics. They will learn about nature and their surroundings.                                               |
| PSO - 2 | Critical Thinking                       | The learner will be familiar with the logical thinking and explanations of various mysteries in nature. They will be familiar with the working principles of different mechanical activities. Overall, it will inculcate a scientific bent of mind. |
| PSO - 3 | Competency for Competitive Examinations | The learner will be competent to face national/international level examinations like UGC-CSIR NET, GATE, JAM, JEST, GRE, TOEFL andUPSC Civil Service Examinations.                                                                                  |
| PSO - 4 | Ethical Thinking                        | The student will acquire a purposeful knowledge of scientific literatureand ethical issues related to physics.                                                                                                                                      |

### Basic Syllabus Structure of IDC

| Semester | Course Name & Code                     | Contents                                        |
|----------|----------------------------------------|-------------------------------------------------|
| 1        | Physics for All - Part 1<br>PY-ID-1113 | Great Indian Scientists and their Contributions |
|          |                                        | Underlying Science of Indian Monuments          |
|          |                                        | Indian Space Programme and its Impact           |
|          |                                        | Beyond Sky                                      |
|          |                                        | Introduction to measurement units               |
| 2        | Physics for All - Part 2<br>PY-ID-2113 | Know your planet - Earth                        |
|          |                                        | World through a Physicist Eye                   |
|          |                                        | Beyond our Sky                                  |
|          |                                        | Light and its related phenomena                 |
| 3        | Physics for All - Part 3<br>PY-ID-3213 | Renewable Energy and Resources                  |
|          |                                        | Wonderful World of Sound and Waves              |
|          |                                        | Physics in Everyday Life                        |
|          |                                        | From Classical to Quantum World                 |

## Course Learning Outcome (CLO)

| Semester | Course Name & Code                    | Course Learning Outcome (CLO) |                                                                                                                                                                                              |
|----------|---------------------------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | Physics for All- Part 1<br>PY-ID-1113 | CLO - 01                      | A student will know about the contribution of Indian Scientists in different fields from ancient days to modern days.                                                                        |
|          |                                       | CLO - 02                      | A learner can now enjoy the famous Indian architecture and monuments by thinking about the underlying physics during their visit in that particular spot.                                    |
|          |                                       | CLO - 03                      | Students can feel proud and gather knowledge by knowing the achievements of our own space agency ISRO.                                                                                       |
|          |                                       | CLO - 04                      | A student will be able to understand the basic concepts of different appliances in everyday life.                                                                                            |
| 2        | Physics for All- Part 2<br>PY-ID-2113 | CLO - 01                      | A student will know about the construction of earth's body and its atmosphere, their significance and importance.                                                                            |
|          |                                       | CLO - 02                      | A learner will get a general idea of the working of various tools and appliances used in our day-to day lifestyle.                                                                           |
|          |                                       | CLO - 03                      | A student can explain the possible states of matter and their phase changing processes, their impact in various phases of weather conditions, various classes and applications of materials. |
|          |                                       | CLO - 04                      | A student will familiar with the world beyond our earth and the history and development of human civilization in case of units and measurements.                                             |
| 3        | Physics for All- Part 3<br>PY-ID-3213 | CLO - 01                      | A student will aware the uses of renewable energy sources and learn about the impact of them in real world.                                                                                  |
|          |                                       | CLO - 02                      | A learner will familiar with the concepts of sound and waves and their practical importance in various instruments and technology.                                                           |
|          |                                       | CLO - 03                      | A student acquires knowledge of working principle of various instruments, tools and appliances used in our day to day life.                                                                  |
|          |                                       | CLO - 04                      | A learner will go through the journey of different major events and the names of important persons behind the event in the history of civil human society.                                   |

### Mapping of Course Learning Outcome (CLO) and Programme Outcome (PO)

| Courses    | CLO     | Programme Outcome (PO) |         |         |         |         |         |         |         |         |          |          |
|------------|---------|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
|            |         | SPO - 1                | SPO - 2 | SPO - 3 | SPO - 4 | SPO - 5 | SPO - 6 | SPO - 7 | SPO - 8 | SPO - 9 | SPO - 10 | SPO - 11 |
| PY-ID-1113 | CLO - 1 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 2 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 3 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 4 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
| PY-ID-2113 | CLO - 1 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 2 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 3 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 4 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
| PY-ID-3213 | CLO - 1 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 2 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 3 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |
|            | CLO - 4 | 3                      | 1       | 1       | 1       | 2       | 2       | 1       | 1       | 1       | 1        | 2        |

### Mapping of Course Learning Outcome (CLO) and Programme Specific Outcome (PSO)

| Courses    | CLO     | Programme Specific Outcome (PSO) |         |         |         |
|------------|---------|----------------------------------|---------|---------|---------|
|            |         | PSO - 1                          | PSO - 2 | PSO - 3 | PSO - 4 |
| PY-ID-1113 | CLO - 1 | 3                                | 2       | 2       | 1       |
|            | CLO - 2 | 3                                | 2       | 2       | 1       |
|            | CLO - 3 | 3                                | 2       | 2       | 1       |
|            | CLO - 4 | 3                                | 2       | 2       | 1       |
| PY-ID-2113 | CLO - 1 | 3                                | 2       | 2       | 1       |
|            | CLO - 2 | 3                                | 2       | 2       | 1       |
|            | CLO - 3 | 3                                | 2       | 2       | 1       |
|            | CLO - 4 | 3                                | 2       | 2       | 1       |
| PY-ID-3213 | CLO - 1 | 3                                | 2       | 2       | 1       |
|            | CLO - 2 | 3                                | 2       | 2       | 1       |
|            | CLO - 3 | 3                                | 2       | 2       | 1       |
|            | CLO - 4 | 3                                | 2       | 2       | 1       |

**COURSE NAME: Physics for All - Part: 1**

**COURSE CODE: PY – ID – 1113**

**TOTAL CREDITS: 3 (Theory: 3)**

## **THEORY**

**Total Lectures - 45**

### **Course Objective:**

*This course provides students to know about the great Indian scientists and their contributions in the various fields of science, History and science behind the well-popular Indian architecture and monuments, get a chance to proud on our achievements of our own space agency ISRO, know about the solar system and its related terminology, development of units and measurements.*

### **Course Learning Outcome:**

- CLO – 01:** *A student will know about the contribution of Indian Scientists in different fields from ancient days to modern days.*
- CLO – 02:** *A learner can now enjoy the famous Indian architecture and monuments by thinking about the underlying physics during their visit in that particular spot.*
- CLO – 03:** *Students can feel proud and gather knowledge by knowing the achievements of our own space agency ISRO.*
- CLO – 04:** *A student will be familiar with the world beyond our earth and the history and development of human civilization in case of units and measurements.*

### **Unit – I: Great Indian Scientists and their contributions (10 lectures)**

- Ancient Era: Aryabhatta, Bhaskaracharya, Budhayana, Nagarjuna, Susruta, Kanada, Varahamihira.
- Medieval Era: Gangadhara, Mughal philosophers, Nilakantha Somasutvan, Sukraniti.
- Modern Era: Srinivasa A. Ramanujan, Jagdish Chandra Bose, Satyendra Nath Bose, Meghnad Saha, Homi Jahangir Bhabha, Vikram A. Sarabhai, A. P. J. Abdul Kalam, Deepak Dhar, Ashok Sen.
- Nobel Laureates of Indian Origin: Sir Chandrasekhara Venkata Raman, Har Gobind Khorana, Subrahmanyam Chandrasekhar, Venkatraman Ramakrishnan.
- Notable Assamese Scientists: Guruprasad Das, Jitendra Nath Goswami.

### **Unit – II: Underlying Science of Indian monuments (5 lectures)**

Konark Sun temple, Shree Jagannatha Temple Puri, Vitthala temple and its musical pillars, Somnath temple and its link to Antarctica, Qutab Minar, Jantar Mantar, Hawa Mahal, Taj Mahal, Ajanta and Ellora Caves, Shiva temples on the same longitude.

### **Unit – III: Indian Space Program and its impact (13 lectures)**

- Birth of Indian space research program, Indian Space Research Organization (ISRO) and its allied institutions, Launching story of first Indian Satellite: Aryabhatta.
- Geostationary and polar satellites.
- Launch vehicles: PSLV and GSLV.

- Major Missions of ISRO: Chandrayan-I, Mangalyan, Chandrayan-II, Launching of 104 satellites, Chandrayan-III, Aditya L1, Gaganyaan (Crew Escape Module), NAVIC.
- INSAT and IRS satellites for telecommunication and disaster management support.
- Artificial satellite and its importance: Weather forecasting, Disaster management, Flood relief and monitoring, Draught Control, Cyclones prediction, Telecommunications, mobile communications, Agriculture sector, Motion of outer earth's objects.

#### **Unit – IV: Beyond Our Sky (10 lectures)**

- Solar System: Formation story of our own solar system, Sun and its basic properties, Solar atmosphere, Corona, Planets and their satellites, Basic Properties of each planet, Pluto is no longer considered as a planet.
- Our own satellite Moon and its properties, Solar Eclipse and Lunar Eclipse, Tide.
- Our own galaxy Milky way.
- Astronomical Telescopes: Hubble Space Telescope, James Web Telescope, Indian Astronomical Observatory, Hanle (Basic Ideas Only).

#### **Unit – V : Introduction to measurement units (7 lectures)**

- Evolution of Units, History of measurements.
- Standardization of measurements of length, mass and time.
- Instruments used in measurements: meter scale, Vernier scale, clocks, balance box.
- Astronomical Units: Light Years, Parsec, Stellar and Solar Masses.

**COURSE NAME: Physics for All - Part: 2**

**COURSE CODE: PY – ID – 2113**

**TOTAL CREDITS: 3 (Theory: 3)**

**THEORY**

**Total Lectures - 45**

**Course Objective:**

*This course is intended to provide the students about the knowledge of our planet earth's structure and atmosphere, physics of our day to day instruments and appliances, matter and its various forms, different types of materials, light and its applications in our everyday life.*

**Course Learning Outcome :**

- CLO – 01:** *A student will know about the construction of earth's body and its atmosphere, their significance and importance.*
- CLO – 02:** *A learner will get a general idea of the working of various tools and appliances used in our day-to day lifestyle.*
- CLO – 03:** *A student can explain the possible states of matter and their phase changing processes, their impact in various phases of weather conditions, various classes and applications of materials.*
- CLO – 04:** *A student will be able to understand the basic concepts of different appliances in everyday life.*

**Unit - I : Know your planet – Earth (10 lectures)**

**Part A: Structure of the Earth**

- Basic properties of the earth, Water and land percentage, Continents and Oceans.
  - Compositional layers: Crust, Mantle, Core.
  - Mechanical layers: Lithosphere, Asthenosphere, Mesosphere, Outer Core.
  - Tectonic plate, Volcano Eruptions, Earthquake, Richter scale, Seismometer, Tsunami.
- The 1950's Earthquake of Assam and its impact.

**Part B: Atmosphere of the Earth**

- Earth's atmosphere and its composition, layers of the atmosphere: Troposphere, Stratosphere, Mesosphere, Thermosphere and Ionosphere.
- Necessity, Importance and significance of each layer from various practical aspects.
- Greenhouse gases, Greenhouse effect and its consequences: Ozone hole, Global warming, Climate change.

## **Unit – II: World through a Physicist Eye (15 lectures)**

- Sir Isaac Newton and his contribution to the development of mechanics and discovery of gravity and gravitation force,
- Application of gravity in various aspects of human civilizations.
- Motion in everyday life: translational and rotational.
- Concept of Work and Energy with practical examples, different forms of energy.
- Discovery of wheels.
- Practical examples of Mechanical tools: lever, pulley, and chains.
- Concept of pressure and its impact in our day to day life, Ideas of hydraulic lift and hydraulic brake, Pressure Cooker.
- Archimedes principle and the legend associated with it, Ideas of floating of ships and sinking of submarines.
- Application of fluid mechanics in everyday life - jet spray, capillarity.

## **Unit – III: Know your surroundings (12 lectures)**

### **Part A: Concept of Matter**

- Different states of matter (solid, liquid and gas) and their basic properties.
- Change of state (Melting, boiling, vaporisation).
- Concept of evaporation, sublimation, and condensation.
- Dew, fog, and occurrence of rain, Formation of cloud.

### **Part B: History and Evolution of materials**

- Starting of human civilization.
- Era of materials: Stone Age, Copper Age, Iron Age.
- Development of materials: Metals and non-metals, Metalloids, Alloys (Basic ideas and examples of each class only).
- Basic Ideas about Advanced Materials: Polymers, Ceramics, Synthetic fibres, Smart materials, Biomaterials, Nanomaterial, Quantum dots.

## **Unit - IV Light and its related phenomena (8 lectures)**

- Concepts of reflection and refraction.
- Concept of image (real and virtual).
- Ideas of mirrors and lenses, Types of mirrors and Lenses, Uses of mirrors and lenses.
- Working of a camera, human eye, power of a lens.
- Historical background of the development of telescope and microscope (stories of Galileo and Leeuwenhoek).
- Basics of dispersion, dispersion in a prism, VIBGYOR and rainbow.
- Scattering of light, Red sky of the sunset, Blue sky at day time, Blue colour of the ocean.

**COURSE NAME: Physics for All - Part: 3**

**COURSE CODE: PY – ID – 3213**

**TOTAL CREDITS: 3 (Theory: 3)**

## **THEORY**

**Total Lectures - 45**

### **Course Objective:**

*A student will aware the uses of renewable energy sources and learn about the impact of them in real world.*

### **Course Learning Outcome:**

**CLO – 01:** *A student will aware the uses of renewable energy sources and learn about the impact of them in real world.*

**CLO – 02:** *A learner will familiar with the concepts of sound and waves and their practical importance in various instruments and technology.*

**CLO – 03:** *A student acquires knowledge of working principle of various instruments, tools and appliances used in our day to day life.*

**CLO – 04:** *A learner will go through the journey of different major events and the names of important persons behind the event in the history of civil human society.*

### **Unit – I: Renewable Energy and Resources (12 lectures)**

- Renewable and non-renewable energy and there natural sources, Need for renewable energy sources and present day status.
- Brief description of renewable energy sources (Solar energy, Wind energy, Hydro energy, Tidal energy, Geothermal energy, and Biomass energy).
- Advantages and disadvantages of renewable energy sources. History and evolution of the concept of sustainable development.
- Consequences of fossil fuel burning - ozone layer depletion, greenhouse effects, global warming.
- Ideas about solar cells and their uses in household and industrial applications, solar heater/cooker (qualitative discussions only).
- Future of renewable energy sources, social issues related to hydropower generation

### **Unit – II: Wonderful World of Sound and Wave (8 lectures)**

- Concept of oscillatory motion, Pendulum of Wall Clocks. Wave, Nature of Wave, Different types of waves.
- Application in different musical instruments: flute, guitar, drum (qualitative). Qualitative definition of frequency, time period, wavelength, velocity of wave.
- Echo in a Hall, Audible range of sound, Concept of ultrasonic waves and its practical applications (bat hunting, SONAR), Supersonic jets.

### **Unit – III: Physics in every day life (13 lectures)**

- Household circuit, usage of fuse and MCB, and importance of earthing. Heating effect of current: Heater and Iron.
- Concept of direct and alternating current.
- Magnet, earth's magnetism, Electric current can act as a magnet; Magnet can also induce current, Concept of electro- magnetic induction. Primary and secondary cells (qualitative).
- Qualitative explanation of generator, motor, and transformer.
- Application in everyday life: Washing machine, Mixer Grinder, Drilling, and Cutting machines. Concepts on conductors, insulators and semiconductors.
- Discovery of X-rays and its applications.
- Superconductor and its applications - Bullet train, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) machines (basic ideas only).
- Basics of communication systems: History and development, Different modes of communications: Satellite communication, Mobile communications, GPS (qualitative discussion only).

### **Unit – IV: From Classical to Quantum World (12 lectures)**

- Theoretical progress and consequent experimental evidence.
- Newton's Era and the contribution of Newton to the major fields of Physics.
- Development of modern physics, about the father of modern physics, discovery of proton, electron, and neutron (qualitative).
- Birth of Quantum Physics and its impact.
- Albert Einstein and Discovery of Relativity. The impact of relativity in modern physics and technology. Marie Curie, discovery of radioactivity and its applications.
- Nuclear energy (qualitative idea only), nuclear holocaust with special reference to Hiroshima and Nagasaki, Chernobyl Disaster.
- Nuclear isotopes and its applications.