Parvatibai Chowgule College of Arts and Science
Autonomous
Accredited by NAAC with Grade 'A' (CGPA Score 3.41 on a 4 Point Scale in 3rd cycle)
Best affiliated College-Goa University Silver Jubilee Year Award

LEARNING OUTCOME-BASED EDUCATION (LOBE)

for

Undergraduate Programme
BSc PHYSICS
(LOCF)

1. Introduction

The rich tradition of Department of Physics hails ever since the establishment of the college; it proclaims the respect of being the first major department since the naissance of the institution. The department of Physics offers B.Sc. degree programme in Physics wherein students are provided with an opportunity to learn number of interesting and application based elective courses apart from core courses. Highly dedicated and enthusiastic faculty; with research background in theoretical as well as experimental Physics; impart quality education with interactive classroom teaching blended with the use of ICT.

2. Objective/Aim of BSc Programme

Mission statement of the department.

The discipline of Physics is basic among the sciences and focuses on the study of natural phenomena and their technological applications. The department offers an undergraduate degree program to provide students a broad-based education in physics. The compulsory courses offered are 'Mechanics-I, 'Heat and Thermodynamics', 'Electricity and Magnetism' and 'Introduction to Mathematical Physics', at the entry level to strengthen the understanding of basic concepts of Physics and mathematical skills required.

The program offers elective courses such as 'Nuclear and Elementary Particle Physics', 'Mathematical Physics', 'Introduction to Special Theory of Relativity', 'Solid State Physics' and 'Computational Physics', designed to provide a sound foundation in Theoretical Physics; whereas the elective courses such as 'Introduction to Material Science', 'Electronics-II', 'Solid State Devices' and 'Instrumentation' are designed to offer a base for Experimental Physics.

The faculty members of the department, with research backgrounds in diversifying areas such as Theoretical Nuclear Physics, Experimental Neutron Physics, Theoretical Condensed Matter Physics and Material Science, facilitate the program to provide a wide range of elective courses.

he infrastructure includes two well equipped laboratories with attached dark rooms and a research laboratory equipped with computers, Hydraulic Press, High Temperature Furnace, Digital Weighing machine, Hall Effect Kit, Electromagnets, Air Track and Three Newtonian Reflecting Telescopes. Learning resources for the theory component and e-journals for practical component of courses are provided online through Moodle, which can be accessed by students from anywhere (CLAAP).

The faculty members impart quality education through interactive classroom teaching blended with effective use of ICT. Innovative teaching techniques like Peer Instruction and Peer tutoring are also followed.
In addition to regular lectures, we also organise 'Talks' on recent trends in Physics, to expose our students to current research areas. We provide a creative and stimulating environment for learning physics through experimental/ theoretical projects aligned to the aptitude of students. We promote self-learning, self-confidence, communication skills, and team work among students through regular presentations, group assignments and participation in student's seminars/ paper presentations at intercollegiate level and state level.
We encourage students to take up internship at D'Art of Science, doing science videos for school children. We motivate students to attend the Science Academy Refresher Course in Experimental Physics, organized by Goa University; which is also recognised as an internship by the Board of Studies. To instil institutional social responsibility in students, we involve them in in-house teaching internship programmes, by organizing educational Outreach Programs for school children during semester breaks. The department also involves the students to participate and benefit from the subject related activities organised by our MoU partner: Department of Physics, Gogate Jogalekar College, Ratnagiri.
This program is for students who are interested to pursue higher studies in Physics/ Electronics/ Computer Applications/ Marine Science and/or, be employable in fields such as Defence, Merchant Navy, Software companies, IT firms, Hardware industries and school teaching. Students who have completed their XII Science with PCM are eligible for this course.
We want technologically savvy students, having a sound background in physics along with Mathematics and Chemistry; at the Higher Secondary level and are highly motivated to learn various concepts of physics, and committed to follow the discipline and work-ethics in the laboratory.

3. **Overview of Department-** About faculty, *infrastructure, facilities, opportunities for students, activities, progression highlights).*

Faculty:

Name and Designation	Qualification	Specialisation
Mrs. Malati Dessai Assistant Professor	M.Sc.	Solid State Physics
Dr. Ananya Das Associate Professor	M.Sc., Ph.D., PGDCA	Theoretical Nuclear Physics and Solid State Physics
Mr. Yatin P. Desai Assistant Professor and Head of the Department	M.Sc., M.Phil.	Experimental Condensed Matter Physics
Dr. Ashish M. Desai Assistant Professor	M.Sc., Ph.D.	Experimental Neutron Physics, Computational Quantum Mechanics
Ms. Pearl Oliveira Assistant Professor	M.Sc.	General Physics
Ms. Suvarna Patil Assistant Professor	M.Sc.	General Physics
Mr. Yashwant Desai Assistant Professor	M.Sc.	General Physics

Infrastructure and Facilities:

The infrastructure includes two well equipped laboratories with attached dark rooms and a research laboratory equipped with computers, Hydraulic Press, High Temperature Furnace, Digital Weighing machine, Hall Effect Kit, Electromagnets, Air Track and three Newtonian reflecting telescopes.

Opportunities for Students:

Students are given opportunity to carry out quality research work in experimental and theoretical Physics as a part of their TYBSc project which has been presented in national and international conferences and also published in reputed journals. Students are encouraged to participate in internship programmes at industries and reputed academic institutions which enables them to get an exposure to the work environment in industries and research institutions respectively. Invited subject talk by eminent speakers provide students with an opportunity to gain broader perspectives in modern trends in Physics. Students are encouraged to hone their life skills by participating in different workshops organised by the Physics department and college. Interclass competitions such as “Physics Day” provide an opportunity for students to build self-confidence, effective communication skills and team work.

Activities:

Department brings out a bi-annual Newsletter **RIPPLES** highlighting interesting and important topics in physics. It provides a platform for students to express their thoughts and communicate their ideas.
Department celebrates Physics Day where students are encouraged to display their talents by organizing activities such as quiz, poster competition, oral presentation etc. Toppers are awarded with prizes and certificates.
Department conducts Annual National Graduate Physics Examination (NGPE). Students clearing this National examination are awarded with certificates.

Progression Highlights:

At the end of the B.Sc. degree programme in physics, students will have an opportunities in:

Higher studies: Post graduation in Physics, Electronics, Marine Science, Computer Application and Business Management.

Integrated Ph.D. programme in Physics at different National institutes.

Teaching: At school and higher secondary level with additional B. Ed. Degree and at College/University level by passing NET/SET and with Ph.D./M.Phil.

Defence: Army, Navy and Air Force.

Industry: Software companies, banking sector and government services.

4. Graduate Attributes-

Some of the characteristic attributes of a graduate in Physics are:

- **Disciplinary knowledge and skills:** Capable of demonstrating
  - (i) good knowledge and understanding of major concepts, theoretical principles and experimental findings in Physics and its different subfields like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology etc.
  - (ii) ability to use modern instrumentation and laboratory techniques to design and perform experiments is highly desirable in almost all the fields of Physics listed above in (i)
- **Skilled communicator:** Ability to transmit complex technical information relating all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in all the basic areas of Physics.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics, and planning, executing and reporting the results of a theoretical or experimental investigation.
- **Team player/worker**: Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in industry and field-based situations.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.
- **Digitally Efficient*:*** Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data.
- **Ethical awareness / reasoning*:*** Capable of demonstrating ability to think and analyse rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behaviour such as fabrication, falsification

or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

- **National and international perspective***:* The graduates should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing towards the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

5. Qualification descriptors-

The graduates should be able to:

- Demonstrate
  - (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science and applications, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;
  - (ii) procedural knowledge that creates different types of professionals related to different areas of study in Physics outlined above, including research and development, teaching and government and public service;
  - (iii) skills in areas related to specialization area relating the subfields and current developments in the academic field of Physics, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.
- Use knowledge, understanding and skills IN Physics for critical assessment of a wide range of ideas and complex problems and issues relating to the various sub fields of Physics.

- Communicate the results of studies undertaken in the academic field of Physics accurately in a range of different contexts using the main concepts, constructs and techniques of the subject of Physics;
- Address one's own learning needs relating to current and emerging areas of study relating to Physics, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge in Physics.
- Apply one's knowledge and understandings relating to Physics and skills to new/unfamiliar contexts and to identify and analyse problems and issues and seek solutions to real-life problems.
- Demonstrate subject-related and transferable skills that are relevant to some of the Physics related jobs and employment opportunities.

6. Programme Learning Outcomes (PLOs)

PLO1 : Strengthen the understanding of basic concepts of Physics and impart required mathematical skills.

PLO2 : Provide a strong base in Experimental Physics to pursue higher studies/research in Experimental Physics.

PLO3 : Provide a sound foundation in Theoretical Physics to pursue higher studies/research in Theoretical Physics

PLO4 : Developing analytical thinking and logical reasoning.

PLO5: Enhancing problem solving skills.

PLO6 : Promote self-learning, self-confidence, communication skills and team work.

PLO7: Enhancing employability through skill enhancement courses.

7. Course Structure

SEMESTER	CORE		ELECTIVE				
I	PHY-I.C-1 Introduction to Mathematical Physics	PHY-I.C-2 Mechanics-I	-------	-------	-------	-------	-------
II	PHY-II.C-3 Heat and Thermodynamic s	PHY-II.C-4 Electricity and Magnetism	-------	-------	-------	-------	-------
III	PHY-III.C-5 Electromagnetic Theory-I	-------	PHY-E1 *Optics	PHY-E2 Modern Physics	PHY-E3 Oscillations, Waves and Sound	PHY-E17 Introduction to Astronomy and Astrophysics	PHY-E8 Instrum entation
IV	PHY-IV.C-6 Quantum Mechanics	-------	PHY-E5 *Electronics-I	PHY-E18 Introduction to Error Analysis	PHY-E4 Properties of Matter and Acoustics	PHY-E7 Computationa l Physics	-------
V	PHY-V.C-7 Electromagnetic Theory-II	-------	PHY-E9 *Solid State Physics	PHY-E10 Thermodynamic s and Statistical Mechanics	PHY-E11 Electronics-II	PHY-E12 Mathematical Physics	PHY-E6 Solid State Devices
VI	PHY-VI.C-8 Atomic and Molecular Physics	-------	PHY-E13 *Mechanics II	PHY-E14 Nuclear and Elementary Particle Physics	PHY-E15 Introduction to Special Theory of Relativity	PHY-E16 Introduction to Material Science	

* BoS Physics recommends these elective courses to be taken by students as a prerequisite to the M.Sc. (Physics) Program.

COURSES FOR STUDENTS OPTING PHYSICS AS MINOR SUBJECT

Semester	Course
I	Mechanics-I
II	Electricity and Magnetism Or Heat and Thermodynamics
III	Modern Physics Or Electromagnetic theory -I
IV	Computational Physics Or Quantum Mechanics
V	Thermodynamics and Statistical Mechanics Or Electromagnetic theory -II
VI	Mechanics II Or Introduction to Materials Science

COURSES OFFERED AS GENERIC ELECTIVE COURSES

Semester	Course Title	Course code when offered as Generic Elective Course
I	Mechanics I	PHY-GEC-1
II	Heat and Thermodynamics	PHY-GEC-2
III	Oscillations, Waves and Sound	PHY-GEC-3
IV	Properties of Matter and Acoustics	PHY-GEC-4

8. Course Description:

S. No.	Course Code	Course Title	Course Description
1.	**PHY-I.C-1**	**Introduction to Mathematical Physics**	This course is aimed to develop basic competence in certain areas of mathematics required for understanding several important topics in physics.
2.	**PHY-I.C-2**	**Mechanics I**	This course provides an introduction to topics in mechanics, which are essential for advanced work in physics. An objective of this course is to train students to think about some of the physical phenomenon in mathematical terms.
3.	**PHY-II.C-5**	**Electromagnetic Theory – I**	This course is aimed to acquaint students with fundamental principles of Electrostatics part of the Electromagnetic Theory.
4.	**PHY-E1**	**Optics**	The course aims to enable the students to develop an understanding towards the properties of light, its nature, its propagation and the different phenomena exhibited by light. The whole branch is divided into: (1) Geometrical Optics involving geometrical consideration of image –formation based on the rectilinear propagation of light and (2) Physical Optics considering the wave nature of light, then explaining the optical phenomena such as Interference, Diffraction and Polarization exhibited by light using suitable theories. The primary aim of this course is to emphasize the different fundamental principles and the techniques used for different optical phenomena.
5.	**PHY-E2**	**Modern Physics**	Modern Physics involves the study of radiation and matter at atomic levels and velocities close to the speed of light. This course will focus on the early development of the theory of atomic structure, wave particle duality, mass spectrographs, accelerators and Lasers. Lectures will help you clarify concepts of modern physics through various conceptual questions and problems.
6.	**PHY-E3**	**Oscillations, Waves and Sound**	Simple harmonic motion is one of the fundamental types of motion that exists in

			nature. The objective of this course is to cover the fundamental physical concepts of Simple harmonic motion, waves and sound.
7.	**PHY-II.C-7**	**Electromagnetic Theory – II**	This course is aimed to acquaint students with fundamental principles of Magnetostatics part of the Electromagnetic Theory.
8.	**PHY-E9**	**Solid State Physics**	This course deals with crystalline solids and is intended to provide students with basic physical concepts and mathematical tools used to describe solids. The course broadly deals with the topics related to structural aspects and the various physical properties of crystalline solids.
9.	**PHY-E10**	**Thermodynamics and Statistical Mechanics**	This course will introduce kinetic theory, classical thermodynamics, probability and statistical methods.
10.	**PHY-E11**	**Electronics-II**	This course aims at introducing students to analog and digital circuits.

9. Course Learning Objectives (CLOs):

S. No.	**Course Code**	**Course Title**	**Course Learning Outcomes (CLOs)** At the end of this course students will be able to:
1.	**PHY-I.C-1**	**Introduction to Mathematical Physics**	**CO1:** Have a good understanding of vector analysis and its application in physics. **CO2:** Have a good grasp on various tests used to test the convergence and divergence of different kinds of series and learn how to expand a function in power series. **CO3:** Understand the basics of complex numbers. **CO4:** Have an understanding of matrix operations and properties of matrices. **CO5:** Learn basics of partial differentiation and its application in physics. **CO6:** Be able to solve ordinary first and second order differential equations important in the physical sciences, **CO7:** familiarize with spherical and cylindrical coordinate systems.

			CO8: Use mathematical techniques to solve several problems in physics and enhance problem solving skills.
2.	**PHY-I.C-2**	**Mechanics I**	**CO1:** develop qualitative and quantitative understanding of Newtonian mechanics in one and two dimensions and solve the Newton equations for simple configurations. **CO2:** understand the Law of Conservation of Linear Momentum and Angular Momentum and apply these laws to understand elastic and inelastic collision, motion of a rocket and Kepler's law. **CO3:** demonstrate the knowledge of work and energy in kinetics **CO4:** understand the Principle of Conservation of Mechanical Energy (for conservative forces) and apply this law to problems of objects moving under the influence of conservative forces. **CO5:** develop ideas of Newtons Law of gravity, gravitational field and potential energy by solving various problems.
3.	**PHY-II.C-5**	**Electromagnetic Theory – I**	**CO1:** Apply vector calculus to understand concepts in electrostatics. **CO2:** Comprehend the interaction between charges in vacuum as well as in medium. **CO3:** Calculate the electric field and electrical potential for discrete charges and continuous distribution of charge. **CO4:** Apply suitable techniques to solve various electrostatic problems. **CO5:** Understand how ferroelectric materials can be used as memory devices.
4.	**PHY-E1**	**Optics**	**CO1**: Apply cardinal points technique and aberration to study the image formation in optical systems **CO2**: Solve numerical problems based on aberration and cardinal points **CO3**: Apply division by wave front and division by amplitude techniques to study interference patterns **CO4**: Solve numerical problems based on interference in thin films **CO5**: Derive conditions for Fresnel class diffraction and Fraunhofer class diffraction

			CO6: Solve numerical problems based on diffraction grating, resolving power of telescope and prism **CO7**: Apply Huygen's theory of double refraction to study the types of crystal **CO8**: Analyze the types of polarized light with help of Nicol Prism and retardation plate **CO9**: Determine optical rotation of sugar solution using Polarimeters
5.	**PHY-E2**	**Modern Physics**	**CO1 :** have an understanding of constituents of an atom and atomic structure. **CO2 :** discuss and interpret experiments that reveal the wave properties of matter. **CO3 :** discuss and interpret experiments that reveal the particle properties of waves and wavelike properties of particle. **CO4:** apply uncertainty principle to solve physics problems **CO5:** understand the working of mass spectrographs and accelerators **CO6:** understand the basic operating principle of the laser and the optical fiber.
6.	**PHY-E3**	**Oscillations, Waves and Sound**	**Course Outcomes :** After successful completion of this course, students will be able to **CO1 :** Set up an equation of motion for simple harmonic motion and obtain its solution. **CO2 :** Explain how superposition of waves leads to different Lissajous figures. **CO3 :** Set and solve the equation of motion for damped and driven damped harmonic oscillators and analyse the nature of oscillations. **CO4:** Understand the dependence of velocity of sound waves on various factors like temperature, pressure, density, humidity. **CO5:** Solve problems for different cases of Doppler effect.
7.	**PHY-II.C-7**	**Electromagnetic Theory – II**	**CO1 :** Calculate magnetic field induction using Biot-Savart's law and Ampere's law. **CO2 :** Interpret bound currents and calculate magnetic fields in matter. **CO3 :** Comprehend microscopic theory magnetism.

			CO4 : Establish the link between electrostatics and magnetostatics using Maxwell's equations. **CO5:** Develop the wave equation for propagation of electromagnetic waves through material media and vacuum at different angles of incidence.
8.	**PHY-E9**	**Solid State Physics**	CO1: Identify bonding types in crystalline solids and correlate the nature of bonding of solid to some of the physical properties associated with it. CO2: Identify different crystal systems and determine structural parameters like unit cell of crystal lattices, translation vectors, atomic packing, crystal planes and directions with help of Miller Indices. CO3: Derive and apply Bragg's law to determine crystal structure. CO4: Derive and apply classical free electron theory of metals to study electrical conductivity CO5: Derive and apply density of energy states to estimate density of free electrons, Fermi energy and mean energy of electron gas at absolute zero CO6: Derive and apply Fermi Free electron gas model in 3 dimensions to study electrical properties of metals. CO7: Apply Kronig-Penney Model and Bloch theory to interpret energy band structures in solids, in particular knowing effective mass and E v/s k relationship. CO8: Differentiate materials with respect to their magnetic properties. CO9: Apply the knowledge gained to solve problems in solid state physics using relevant mathematical tools.
9.	**PHY-E10**	**Thermodynamics and Statistical Mechanics**	**CO1 :** Understand basics of kinetic theory of gases and thermodynamic potentials. **CO2 :** Understand Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics and its application to the classical gas, electrons in a metal and blackbody radiation **CO3 :** Understand the specific heat of solids by invoking statistical mechanics.
10.	**PHY-E11**	**Electronics-II**	**CO1** : Analyse AC circuits and apply the techniques in designing circuits. **CO2:** Generate different kinds of waves using OP-Amp **CO3:** Understand the basic concepts of 555 timer.

			CO4: Develop the ideas of monolithic linear regulators and understand different types of voltage regulators in LM series **CO5:** Apply binary operations to different digital circuits **CO6:** Understand the clocked digital electronics and its applications in different types of counters

10. Teaching-Learning-Evaluation Pedagogies:

MODES OF TEACHING
1. Lecture method 2. ICT supplemented teaching. 3. Group Learning activities 4. Experiential Learning 5. Problem Based Learning 6. Flipped Classroom 7. Student Seminars 8. Group Discussions 9. Lab Experiments 10. Project based learning

11. Activities of the Department:

- Department brings out a bi-annual Newsletter **RIPPLES** highlighting interesting and important topics in physics. It provides a platform for students to express their thoughts and communicate their ideas.
- Department celebrates Physics Day where students are encouraged to display their talents by organizing activities such as quiz, poster competition, oral presentation etc. Toppers are awarded with prizes and certificates.
- Department conducts Annual National Graduate Physics Examination (NGPE). Students clearing this National examination are awarded with certificates.
- Department conducts Invited subject talks by eminent speakers to provide students with an opportunity to gain broader perspectives in modern trends in Physics.
- Department conducts workshops on various Physics related topics. Students are encouraged to hone their skills by participating in such workshops.

12. Course Syllabus: [odd semester]

Parvatibai Chowgule College of Arts and Science (Autonomous)
Margao, Goa

Syllabus for

Semester-I, III and V

of the undergraduate degree courses

in

Physics

(2020-2021)

Course Title : **Introduction to Mathematical Physics**

Course Code : **PHY-I.C-1**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives : To develop basic competence in certain areas of mathematics required for understanding several important topics in physics.

Course Outcomes : At the end of this course students will be able to:

CO1: Have a good understanding of vector analysis and its application in physics.

CO2: Have a good grasp on various tests used to test the convergence and divergence of different kinds of series and learn how to expand a function in power series.

CO3: Understand the basics of complex numbers.

CO4: Have an understanding of matrix operations and properties of matrices.

CO5: Learn basics of partial differentiation and its application in physics.

CO6: Be able to solve ordinary first and second order differential equations important in the physical sciences,

CO7: familiarize with spherical and cylindrical coordinate systems.

CO8: Use mathematical techniques to solve several problems in physics and enhance problem solving skills.

Theory:

Unit I **[15 h]**

1. **Infinite Series and Power Series** **[8 h]**
   Geometric Series and other infinite series. Convergent and Divergent Series. Testing series for convergence. Power series. Expanding functions in power series. Techniques for obtaining power series expansion.
   [Boas 1.1-1.7, 1.10-1.13]

2. **Complex Numbers** **[4 h]**
   Real and imaginary Parts of a complex number. Complex plane. Complex algebra. Euler's formula. Powers and roots of complex numbers. Exponential and trigonometric functions.
   [Boas 2.1-2.5, 2.9-2.11]

3. **Coordinate Systems** **[3 h]**
   Plane polar coordinates. Cylindrical and Spherical polar coordinates.
   [Harper 1.6.6, Riley 8.9]

Unit II **[15 h]**

1. **Vector Algebra** **[5 h]**
   Scalars and vectors. Basis vectors and components. Multiplication of Vectors. Equation of lines and planes. Using vectors to find distances.
   [Boas 3.4-3.5]

2. **Vector Analysis** **[10 h]**

Application of vector multiplication. Triple products. Differentiation of vectors. Gradient, divergence and curl of a vector. Line integrals. Divergence theorem. Curl and Stokes theorem.
[Boas 6.1-6.11]

Unit III **[15 h]**

1. **Partial Differentiation** **[6 h]**

Definition of the partial derivative. Total differentials. Exact and inexact differentials. Theorems of partial differentiation. Chain rule. Thermodynamic relations. Differentiation of Integrals.
[Riley 4.1-4.5, 4.10-4.11]

2. **Ordinary Differential Equation** **[9 h]**

Introduction. Linear differential equation of the first order. Homogenous and inhomogeneous linear differential equation of the second order.
[Boas 8.1-8.6 and Harper 5.1-5.2]

Experiments: (Minimum Six)

1. Introduction Error Analysis: Propagation of Errors
2. Statistical Analysis of Random measurement
3. Simulation of Radioactive Decay using Rolling of Dice
4. Plotting of various algebraic and trigonometric functions using Excel.
5. Curve fitting using Excel.
6. Interpretation of graphs.
7. Solving Integration, Ordinary Differential Equation and Matrices using Mathematica.
8. Tutorial on vector analysis
9. Tutorial on infinite series
10. Tutorial on differential equations
11. Tutorial on matrices and partial differentiation

References:

1. K. F. Riley, M. P. Hobson and S. J. Bence, *Mathematical Methods for Physics and Engineering* (Cambridge University Press, 1998)
2. Mary L. Boas, *Mathematical Methods in Physical Sciences* (John Wiley and Sons, 3rd Edition)
3. Charlie Harper, *Introduction to Mathematical Physics*- (Prentice Hall)

Additional References:

1. B. D. Gupta, *Mathematical Physics* (Vikas Publishing House, 2004)
2. M. Spiegel, S. Lipschutz, D. Spellman, *Schaum's Outline of Vector Analysis,* (Mc-Graw Hill Education, 2009)

Web References:

1. https://ocw.mit.edu/resources/res-18-007-calculus-revisited-multivariable-calculus-fall-2011/
2. https://nptel.ac.in/courses/111108081/
3. https://www.math.upenn.edu/~deturck/m104/notes/week6.pdf
4. http://tutorial.math.lamar.edu/Classes/CalcIII/CalcIII.aspx
5. http://home.iitk.ac.in/~peeyush/102A/Lecture-notes.pdf
6. http://www.jimahoffman.com/MathB30/Matrices/Matrix1.pdf

Course Title : Mechanics I

Course Code : PHY-I.C-2

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives : This course provides an introduction to topics in mechanics, which are essential for advanced work in physics. An objective of this course is to train students to think about some of the physical phenomenon in mathematical terms.

Course Outcomes : At the end of this course students will be able to:

CO1: develop qualitative and quantitative understanding of Newtonian mechanics in one and two dimensions and solve the Newton equations for simple configurations.
CO2: understand the Law of Conservation of Linear Momentum and Angular Momentum and apply these laws to understand elastic and inelastic collision, motion of a rocket and Kepler's law.
CO3: demonstrate the knowledge of work and energy in kinetics
CO4: understand the Principle of Conservation of Mechanical Energy (for conservative forces) and apply this law to problems of objects moving under the influence of conservative forces.
CO5: develop ideas of Newtons Law of gravity, gravitational field and potential energy by solving various problems.
Theory:

UNIT – I: Newton's Laws of Motion, Projectiles and Charged Particles [20 h]

1. **Newton's Laws of Motion [10 h]**
   Brief description of classical view of Space and Time (vector operations). The concept of Mass and Force. Newton's First and Second Laws; Inertial frames. Equations of motion. Interpretation of Newton's third Law as Conservation of Momentum. Newton's Second Law in Cartesian coordinates and in two dimensional Polar coordinates. Applications of Newtons Laws: Atwood Machine, Free fall near surface of the earth, simple harmonic motion and time dependent force.
   [Taylor 1.1-1.7, Kleppner 2.4]

2. **Projectiles and Charged Particles** **[10 h]**
   Motion of projectile in air resistance/drag (function of velocity.) Linear Air Resistance. Horizontal and vertical motion with linear drag, Trajectory and Range in a Linear Medium. Quadratic Air Resistance. Horizontal motion with quadratic drag (ignoring gravity), Motion of a charged particle with a velocity perpendicular to the direction of a uniform constant (1) electric field, (2) magnetic field and (3) electric and magnetic field (crossed) in mutually perpendicular directions. Lorentz force.
   [Taylor 2.1 - 2.7, Symon 3.17]

UNIT – II: Momentum, Angular Momentum, Gravitation Field and potentials [15 h]

3. **Momentum and Angular Momentum** **[7 h]**
   Principle of conservation of momentum (Elastic and Inelastic collision), Analysis of Rocket motion. The Centre of Mass, Angular Momentum for a Single Particle. Kepler's second law as a consequence of conservation of angular momentum.
   [Taylor 3.1-3.5]

4. **Gravitation Field and potentials** **[8 h]**
   Newton's Law of Gravitation. Gravitational field. Gravitational potential energy. Equipotential surface. Gravitational potential and field due to a (1) thin spherical shell, (2) uniform hollow sphere and (3) thin circular plate.

UNIT – III: Work and Energy **[10 h]**

5. **Work and Energy** **[10 h]**
   Kinetic Energy and Work: Work energy theorem. Potential Energy and Conservative Forces. Force as a Gradient of Potential Energy, Time dependent potential energy (one dimension). Energy for Linear One-Dimensional Systems. Curvilinear one-dimensional systems. Energy of interaction of two particles in one dimension.
   [Taylor 4.1-4.3, 4.5-4.7, 4.9]

Experiments: (Minimum Six)

1. Dimensions of different solid body
2. Moment of Inertia of a flywheel
3. Atwood Machine
4. Verification of Newton's Second Law using Air Track
5. Conservation of linear momentum using Air Track
6. Spring Mass System: Determining the Spring Constant
7. Simple Pendulum
8. Determining "**g**" using time of flight method using Python

References:

1. John Taylor, *Classical Mechanics,* (University Science Books, 2004)
2. Kleppner and Kolenkow, *Introduction to Mechanics*,(Cambridge University Press, 2013)
3. K. R. Symon, *Mechanics* (Addison Wesley, 1971)
4. Brij Lal and N. Subrahmanyam, *Mechanics and Electrodynamics*, (S. Chand and Company LTD , 2005)

Additional References:

1. Kittle and Knight, Mechanics (Berkeley Physics Course, Vol. 1), (McGraw Hill Education, 2011)
2. D. S. Mathur, *Mechanics* (S. Chand & Co., 2005)
3. R. G. Takawale and P. S. Puranik, *Introduction to Classical Mechanics*, (Tata McGraw-Hill, 1997)
4. Javier E. Hasbun, *Classical Mechanics* (Jones and Bartlett India Pvt. Ltd. 2010)
5. Atam Arya, *Introduction to Newtonian Mechanics,* (Addison-Wesley, 1997))
6. R. G. Takawale and P. S. Puranik, *Introduction to Classical Mechanics* (Tata McGraw-Hill, 1997)
7. Javier E. Hasbun, *Classical Mechanics* (Jones and Bartlett India Pvt. Ltd. 2010)

Web References:

1. https://nptel.ac.in/courses/122106027/
2. https://ocw.mit.edu/courses/physics/8-01sc-classical-mechanics-fall-2016/
3. https://www.khanacademy.org/science/ap-physics-1/
4. https://www.feynmanlectures.caltech.edu/I_13.html
5. http://hep.physics.wayne.edu/~harr/courses/5200/f07/lecture06.htm

Course Title : **Electromagnetic Theory – I**

Course Code : **PHY-III.C-5**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : Electricity and Magnetism (PHY-II.C-4) and Introduction to Mathematical Physics (PHY-I.C-1)

Course Objectives : To acquaint students with fundamental principles of Electrostatics part of the Electromagnetic Theory.

Course Outcomes : At the end of this course students will be able to:
CO1: Apply vector calculus to understand concepts in electrostatics.
CO2: Comprehend the interaction between charges in vacuum as well as in medium.
CO3: Calculate the electric field and electrical potential for discrete charges and continuous distribution of charge.
CO4: Apply suitable techniques to solve various electrostatic problems.
CO5: Understand how ferroelectric materials can be used as memory devices.

Theory:

UNIT – I: Vector Analysis [10 h]

1. **Vector Analysis** **[10 h]**

Vector Algebra: Vector Operations, Vector Algebra: Component form, Triple Products, Position, Displacement and Separation Vectors, Differential Calculus: Ordinary Derivatives, Gradient, The Operator $\vec{\nabla}$, The Divergence and Curl, Product Rules, Second Derivatives, Integral Calculus: Line, Surface and Volume Integrals, The fundamental Theorem for Divergences, The fundamental Theorem for Curls, Different Co-ordinate Systems: Cartesian Co-ordinate System, Cylindrical Co- ordinate System, Spherical Co-ordinate System, Some Useful Vector Identities with Proofs.

[Ref. No. 1 pp. 1 – 8, 13 – 22, 28]

[Ref. No. 2 pp. 20, 26 30-31, 36]

UNIT – II: Electrostatics and Techniques to Solve Electrostatic Problems [20 h]

2. Electrostatics [12 h]

The Electric Field: Coulomb's Law, The Electric Field, Continuous Charge Distributions, Divergence and Curl of Electrostatic Fields: Field Lines, Flux and Gauss's Law, The Divergence of E, Applications of Gauss's Law, The Curl of E, Electric Potential: Introduction to Potential, Poisson's Equation and Laplace's Equation, Potential of a Localized Charged Distribution, Summary: Electrostatic Boundary Condition, Work and Energy in Electrostatics: Work Done to Move a Charge, The Energy of a Point Charge Distribution, The Energy of a Continuous Charge Distribution, Comments on Electrostatic Energy, Conductors: Basic Properties of Conductor, Induced Charges, Surface Charge and the Force on a Conductor, Capacitors.

[Ref. No. 1, pp. 58 – 103]

3. Techniques to Solve Electrostatic Problems [8 h]

Poisson's Equation, Laplace's Equation: Laplace's Equation in One Dimension, Laplace's Equation in Two Dimensions, Laplace's Equation in Rectangular Co-ordinates, Solution to Laplace's Equation in Spherical Co-ordinates (Zonal Harmonics), Conducting Sphere in Uniform Electric Field, Electrostatic Images: Point Charge and Conducting Sphere, Line Charge and Line Images.

[Ref. No. 3 pp. 51 – 67]

UNIT – III: Electrostatic Field in Matter and Microscopic Theory of Dielectrics [15 h]

4. Electrostatic Field in Matter [8 h]

Polarization, Gauss's Law in a Dielectric, Electric Displacement Vector, Electric Susceptibility and Dielectric Constant, Boundary Conditions on the Field Vectors, Boundary Value Problems Involving Dielectric, Dielectric Sphere in a Uniform Electric Field

[Ref. No. 3 pp. 75 – 93]

5. Microscopic Theory of Dielectrics **[7 h]**

Molecular field in a dielectric: Clausius Mossotti Relation, Polar and Non-Polar Molecules, Induced Dipoles, Langevin's Debye Formula, Permanent Polarization, Ferroelectricity.

[Ref. No. 3 pp. 101 – 109]

Experiments: (Minimum Six)

1. Van-de-graff Generator. [Demonstration]
2. Measurement of dielectric constant and susceptibility of liquid using parallel metal plates.
3. Measurement of dielectric constant and susceptibility of liquid using coaxial metal tubes.
4. Measurement and Study of variation of dielectric constant of $BaTiO_3$ ferroelectric and determination of its Curie temperature.
5. E and D measurement for a parallel plate capacitor and calculation of dielectric constant.
6. Law of Capacitance using Dielectric Constant Measurement Kit.
7. Absolute capacity by ballistic galvanometer.
8. C_1/C_2 by De-Sauty's method using ballistic galvanometer.
9. Dipole Moment and Polarizability of Benzene.

References:

1. Griffiths D. J., Introduction to Electrodynamics, Prentice Hall of India, 3rd Ed. (2011)

2. Harper Charlie, Introduction to Mathematical Physics, Prentice Hall of India, 5th reprint, (1993)

3. Reitz J. R., Milford F. J., Christy R. W., Foundations of Electromagnetic Theory, Addison-Wesley Publishing Company, 3rd Ed., (1979)

Additional Reference:

1. Mukherji U., Electromagnetic Field Theory and Wave Propagation, Narosa Publishing House, (2008)

Web References:

1. https://nptel.ac.in/courses/115101005/
2. https://swayam.gov.in/nd1_noc19_ph08/preview
3. https://ocw.mit.edu/courses/physics/8-07-electromagnetism-ii-fall-2012/lecture-notes/
4. https://www.feynmanlectures.caltech.edu/II_10.html
5. https://www.iiserkol.ac.in/~ph324/ExptManuals/DielectricConstant.pdf

Course Title : **Optics**

Course Code : **PHY-E1**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Nil**.

Course Objective: The course aims to enable the students to develop an understanding towards the properties of light, its nature, its propagation and the different phenomena exhibited by light. The whole branch is divided into: (1) Geometrical Optics involving geometrical consideration of image –formation based on the rectilinear propagation of light and (2) Physical Optics considering the wave nature of light, then explaining the optical phenomena such as Interference, Diffraction and Polarization exhibited by light using suitable theories. The primary aim of this course is to emphasize the different fundamental principles and the techniques used for different optical phenomena.

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

CO1: Apply cardinal points technique and aberration to study the image formation in optical systems
CO2: Solve numerical problems based on aberration and cardinal points
CO3: Apply division by wave front and division by amplitude techniques to study interference patterns
CO4: Solve numerical problems based on interference in thin films
CO5: Derive conditions for Fresnel class diffraction and Fraunhofer class diffraction
CO6: Solve numerical problems based on diffraction grating, resolving power of telescope and prism
CO7: Apply Huygen's theory of double refraction to study the types of crystal
CO8: Analyze the types of polarized light with help of Nicol Prism and retardation plate
CO9: Determine optical rotation of sugar solution using Polarimeters

Theory:

Unit-I: Geometrical Optics **[15 h]**

I.1: Fundamentals of Reflection and Refraction [6 h]

Refractive index and optical path, Fermat's Principle of least time, Derivation of the laws of reflection and refraction using Fermat's Principle.
Lenses: thin and thick lenses, Lens equation, Lens maker's formula, Cardinal points of an optical system, Combination of coaxially placed two thin lenses (equivalent lenses) (including derivation for focal length and cardinal points).

[Subhramanyam; Chapter.1: 1.6, 1.7; Sing; Chapter.1: 1.2, 1.3, 1.4; Subhramanyam; Chapter.4: 4.8, 4.9, 4.10, 4.11, 4.12, 4.15, 4.17; Chapter.5: 5.2, 5.2.1, 5.2.2, 5.2.3, 5.3, 5.10, Chapter.6: 6.1, 6.2]

I.2: Lens Aberrations [5 h]

Introduction, Types of aberrations: monochromatic and chromatic aberration, Monochromatic aberration and its reduction: Spherical aberration, Types of chromatic aberration: Achromatism (lenses in contact and separated by finite distance).

[Subhramanyam; Chapter.9: 9.1, 9.2, 9.5, 9.5.1, 9.10, 9.11, 9.12, 9.13]

I.3: Optical Instruments [4 h]

Objective and Eyepiece, Huygen’s eyepiece, Ramsden’s eyepiece, Telescopes, Refracting and Reflecting type of telescopes and Constant deviation Spectrometer.

[Subhramanyam; Chapter.10: 10.8, 10.10, 10.10.1, 10.11, 10.11.1,10.12, 10.15, 10.15.1, 10.16, 10.16.1, 10.17]

Unit-II: Interference and Diffraction [20 h]

II.1: Introduction to Interference and Interference in Thin Films [6 h]

Superposition of waves, Interference, Coherence, Conditions for Interference, Techniques of obtaining Interference, Young’s Double Slit Experiment, Phase Change on reflection: Stoke’s law.

[Subhramanyam:Chapter.14: 14.3, 14.4, 14.4.2, 14.4.4, 14.6, 14.7, 14.8 and Singh Ref.2: Chapter6: 6.3]

Thin Film, Interference due to reflected and transmitted lights in thin films: Plane Parallel Film, Wedge-shaped Film, Newton’s Rings, Types of fringes.

[Subhramanyam: Chapter.15: 15.1, 15.2, 15.2.1 - 15.2.5, 15.3, 15.4, 15.5, 15.5.1 - 15.5.4, 15.6, 15.6.1 - 15.6.9]

II.2: Interferometry [3 h]

Michelson’s Interferometer: Principle, Construction, Working, Circular Fringes, Localised Fringes, White Light Fringes, Application of Michelson’s Interferometer: Measurement of Wavelength and Determination of the difference in the wavelength of two waves.

[Subhramanyam; Chapter.15: 15.7, 15.7.1 - 15.7.5, 15.8, 15.8.1, 15.8.2]

II.3: Introduction to Diffraction and Fresnel Class Diffraction [5 h]

Difference between Interference and Diffraction, Types of diffraction: Fresnel Class and Fraunhoffer Class.

[Subhramanyam; Chapter.17: 17.6, 17.7 and Sing;: Chapter7: 7.5, 7.6]

Diffraction of Light (Fresnel Class): Division of cylindrical wave-front into Fresnel’s half period strips, Diffraction at straight edge, Diffraction at a narrow wire.

[Singh: Chapter.7: 7.9, 7.10, 7.11]

II.4: Fraunhoffer Class Diffraction and Resolving Power of optical Instruments [6 h]

Diffraction at a single slit (Central maximum, Secondary maxima and Secondary minima), Diffraction at double slit, Distinction between single slit and double slit diffraction patterns, Missing orders in a double slit diffraction pattern, Diffraction at N slits(only conceptual), Determination of wavelength of a spectral line using Plane Transmission Grating. Resolving Power, Rayleigh’s criterion, Resolving power of telescope and Resolving Power of Prism.

[Subhramanyam: Chapter.18: 18.2, 18.2.1, pg.431 to 433, 18.4, 18.4.1, 18.4.2, 18.4.3, 18.7, 18.7.1, 18.7.2, 18.7.6 and Chapter.19: 19.1, 19.2, 19.6, 19.7, 19.11]

Unit-III: Polarization **[10 h]**

III.1: Production and Analysis of Polarized lights [7 h]

Polarized Light, Natural Light, Production of Linearly Polarised Light, Anisotropic Crystal, Calcite Crystal, Huygens Theory of Double Refraction in Uniaxial crystal, Nicol prism- its fabrication, working and use, Types of Polarized Light, Retardation plates - Quarter wave plate and Half wave plate, Production of Elliptically and Circularly Polarized Lights, Detection of plane, circularly, elliptically polarized lights, Analysis of polarized light,

III.2: Polarimeter [3 h]

Optical activity, Specific rotation, Simple Polarimeter, Laurent's Half-Shade Polarimeter.

[Subhramanyam: Chapter.20: 20.3, 20.4, 20.5, 20.5.1 to 20.5.5, 20.7, 20.8, 20.8.1 to 20.8.3, 20.9, 20.9.1, 20.9.2, 20.6.1, 20.6.3, 20.15, 20.17.1, 20.17.2, 20.18, 20.18.1, 20.19, 20.19.1, 20.20, 20.24, 20.24.1, 20.25, 20.26]

Experiments: (Minimum six)

1) Cardinals points of Two lenses
2) Prism Spectrometer: Optical levelling, Angle of Prism
3) Dispersive power of prism
4) Newton's Rings
5) Wedge shaped air film
6) Single Slit Diffraction using LASER/Sodium source.
7) Diffraction Grating using LASER/Sodium source.
8) Malus's Law using LASER source.
9) Brewster's Law using LASER source.
10) Polarimeter (Demonstration)
11) Lloyd's Mirror/Biprism (Demonstration)
12) Cylindrical Obstacle (Demonstration)

References:

1. Subhramanyam N., Lal Brij, Avadhanulu M. N., A Text book of Optics, S. Chand & Company Ltd., New Delhi, Firstmulticolour Edition (2006).
2. Singh S. P. and Agarwal J. P., Optics, PragatiPrakashan, 8th Edition (2001).

Additional References:

1. Mathur B. K., Principles of Optics, New Global Printing Press, Kanpur.
2. GhatakAjoy, Optics, Tata McGraw-Hill Publicashing Company Ltd. (1977)
3. Jenkins F. A. and White H. E., Fundamentals of Optics, Tata McGraw-Hill Publishing Company Ltd., (1981)

Web References:

1. https://ocw.mit.edu/courses/mechanical-engineering/2-71-optics-spring-2009/video-lectures/

2. https://www.youtube.com/playlist?list=PLkzOLGQfSuu0L7NRVSxXrMd73NDc48ILb
3. https://www.youtube.com/playlist?list=PL9jo2wQj1WCP2eeRb8UacmKJy850Y9DYQ
4. https://www.youtube.com/playlist?list=PLX2gX-ftPVXWA5TjEhVQSQQzZ-5_5Nui8
5. https://www.youtube.com/watch?v=htSPI7YHnP4&list=PLD707C7AF1A0BC358
6. https://www.youtube.com/watch?v=v1U38n52h9A&list=PLA435953DF9CC6BB9

Course Title : **Modern Physics**

Course Code : **PHY-E2**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Nil**.

Course Objectives:

Modern Physics involves the study of radiation and matter at atomic levels and velocities close to the speed of light. This course will focus on the early development of the theory of atomic structure, wave particle duality, mass spectrographs, accelerators and Lasers. Lectures will help you clarify concepts of modern physics through various conceptual questions and problems.

Course Outcomes: At the end of this course students will be able to:

CO1 : have an understanding of constituents of an atom and atomic structure.
CO2 : discuss and interpret experiments that reveal the wave properties of matter.
CO3 : discuss and interpret experiments that reveal the particle properties of waves and wavelike properties of particle.
CO4: apply uncertainty principle to solve physics problems
CO5: understand the working of mass spectrographs and accelerators
CO6: understand the basic operating principle of the laser and the optical fiber.
Theory:

Unit I **[15 h]**

1. **Electrons, Nucleus and Atoms:** [4 h]
   Determination of e/m for cathode rays. Thomson's model of the atom and qualitative discussion of alpha scattering experiment. Rutherford's model of the atom. Determining upper limit to nuclear dimension. Electron orbits. Failure of Classical Physics.
   [Rajam: Pages 33-36, 44-50, Beiser: 5.1, 5.3, 5.5-5.7]

2. **Brief review of Atomic models:** [6 h]
   Atomic Spectra. Frank-Hertz experiment. The Bohr Atom: Quantization of energy. Bohr-Sommerfeld model. Nuclear motion and reduced mass. Bohr's Correspondence Principle.
   [**Beiser: 6.1, 6.3-6.8]**

3. **Particle Properties of waves:** [5 h]
   Concepts of Blackbody radiation.The Photoelectric effect.Compton Effect.Experimental verification of the Photoelectric effect.
   [Singh: 1.1-1.3, Beiser: 3.1,3.2, 3.5, Muregeshan: 8.5]

Unit II **[15 h]**

1. **De Broglie's Postulate - Wavelike properties of Particles:** [9 h]
   a. **Dual nature of matter:** Experiments with bullets, waves and electrons. The interference of electron waves. Watching the electrons.
   [Feynman: 1.1-1.6]
   b. Matter Waves: De Broglie's postulate. Davisson and Germer experiment. Electron diffraction experiment of G. P. Thomson. Review of the Bohr's postulate about stationary states in the light of De Broglie's concepts.
   [Eisberg: 3.1], [Singh: 2.8]
   c. Properties of Matter waves: Wave and group velocities. Relation between the group velocity and phase velocity. Velocity of De Broglie wave. Wave packet and its motion in one dimension.
   [Singh: 2.3-2.5, 2.9]

2. **Heisenberg's Uncertainty Principle:** [6 h]
   Uncertainty principle. Elementary proof of Heisenberg's uncertainty relation between position and momentum. Elementary proof of Heisenberg's uncertainty relation between energy and time. Illustration of Heisenberg's uncertainty principle with thought-experiments. Consequences of the uncertainty relation.

   [Singh: 3.1-3.5]

Unit III **[15 h]**

1. **Measurement of Mass and accelerators** [6 h]

   Measurement of Mass: Thomson's positive ray analysis, Dempster's Mass spectrometer, Bainbridge Mass spectrograph.

   Linear accelerator and Cyclotron.

   [**Rajam: pg. 227-233, 240-244, Muregeshan: 30.3, 30.4]**

2. **Lasers:** [9 h]
   Attenuation of light in an optical media. Thermal Equilibrium. Interaction of light with matter. Einstein's A and B coefficients and their relations. Population inversion. Principal pumping schemes. Ruby Laser, He-Ne Laser and Semiconductor laser. Applications of Laser.
   Optical fibres: Optical fibre, Total internal reflection, Propagation of light through optical fibre, Losses in optical fibre.
   [Subrahmanyam: 22.1-22.11,22.15, 22.16.1, 22.16.3, 22.7, 24.1-24.4, 24.15]

Experiments: (Minimum Six)

1. Determination of e/m of electrons using Thomson's method.
2. Measurement of k/e.
3. Measurement of diameter of Lycopodium powder.
4. To determine wavelength of Laser source by diffraction of single slit.
5. To determine wavelength of Laser source by diffraction of double slit.
6. Frank Hertz Experiment.
7. Photoelectric effect.
8. IV Characteristics of LASER
9. Optical fibre: Numerical aperture
10. Bending loss in optical fibre

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.
2. Feynman, R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
3. Murugeshan, R 2009, *Modern Physics*, S. Chand and Company limited, New Delhi.
4. Rajam, J. 2000, *Atomic Physics*, S. Chand and Company limited, New Delhi.
5. Subrahmanyam, N., Lal, B. and Avadhanulu, M. 2004, *A Textbook of Optics*, S. Chand and Company limited, New Delhi.
6. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics,* S. Chand, New Delhi.

Additional References:

1. Ghatak 2012, *Optics,* Mcgraw Hill Education, India.
2. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. McGraw-Hill Book Company, New Delhi.
3. Tipler, P. 2012, *Modern Physics*, WH Freeman, New York.

Web References:

1. https://hcverma.in/QuantumMechanics
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
3. https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/
4. https://www.youtube.com/watch?v=VLU4dntonhE&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1
5. https://phet.colorado.edu/en/simulations/category/physics

Course Title : **Oscillations, Waves and Sound**

Course Code : **PHY-E3**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Prerequisite : **Nil**

Course Objectives : Simple harmonic motion is one of the fundamental types of motion that exists in nature. The objective of this course is to cover the fundamental physical concepts of Simple harmonic motion, waves and sound.

Course Outcomes : After successful completion of this course, students will be able to
CO1 : Set up an equation of motion for simple harmonic motion and obtain its solution.
CO2 : Explain how superposition of waves leads to different Lissajous figures.
CO3 : Set and solve the equation of motion for damped and driven damped harmonic oscillators and analyse the nature of oscillations.
CO4: Understand the dependence of velocity of sound waves on various factors like temperature, pressure, density, humidity.
CO5: Solve problems for different cases of Doppler effect.

Theory:

UNIT – I: Undamped free oscillation **[15 h]**

1. **Undamped free oscillation** **[15 h]**

   Different type of equilibria (Stable, unstable and neutral equilibrium). Periodic oscillations and potential well.
   [Mathur: 5.9]

   Differential equation for simple harmonic oscillator and its solutions. Energy of the harmonic oscillator.
   [Taylor: 5.1-5.2]

   Examples of simple harmonic oscillations: spring and mass system, simple and compound pendulum, torsional pendulum, bifilar oscillations, Helmholtz resonator.
   [Mathur: 7.7.1-7.7.5]

   Superposition of two simple harmonic motions of the same frequency along the same line. Superposition of two mutually perpendicular simple harmonic vibrations of the same frequency. Superposition of two mutually perpendicular simple harmonic vibrations and having time periods in the ratio 1:2. Uses of Lissajous' figures.
   [Subrahmanyam: 2.1, 2.2, 2.4, 2.6, 2.9]

UNIT – II: Damped Oscillations and Driven Damped Oscillations [15 h]

1. **Damped Oscillations [5 h]**
   Introduction. Differential equation of damped harmonic oscillator and its solution, discussion of different cases (Strong, weak and Critical damping).Logarithmic decrement. Energy equation of damped oscillations. Power dissipation. Quality factor.

   [Taylor: 5.4 and Mathur: 8.2-8.4]

2. **Driven Damped Oscillations [5 h]**
   Introduction, Differential equation of forced oscillation and its solution (transient and steady state). Resonance. Width of the resonance; the Q factor. The phase at resonance. Velocity resonance.
   [Taylor: 5.5-5.6 and Mathur: 8.9]
3. **Coupled Oscillations [5 h]**
   Coupled oscillations. Normal Coordinates. Energy of coupled oscillations.

UNIT – III: Waves and Sound and Doppler Effect [15 h]

4. **Waves and Sound [10 h]**
   Transverse vibrations in strings. Velocity of longitudinal waves in gases. Newton's formula for velocity of sound. Velocity in a homogeneous medium. Laplace's correction. Kundt's tube-determination of velocity of sound in a gas and in solids. Intensity level and Bel and Decibel.

   Production and detection of Ultrasonic waves and its applications

   [Khanna 4.2, 5.3-5.5, 11.1, 11.3, 12.1-12.4, 19.6 and Subrah.: 11.23 11.25,11.27]

5. **Doppler Effect: [5 h]**
   Explanation of Doppler effect in sound. Observer in rest and source in motion. Source at rest and observer in motion. When both source and observer are in motion. Effect of wind velocity. Doppler effect in light. Applications of Doppler effect.
   [Subrahmanyam: 8.1-8.6]

Experiments: (Minimum Six)

1. To determine the equivalent length of the Kater's pendulum and the acceleration due to gravity using a resonance pendulum.
2. To determine the damping constant using Damped harmonic oscillator
3. To determine the velocity of Sound using Helmholtz resonator
4. To determine the value of acceleration due to gravity using a bar pendulum.
5. To determine the frequency of AC mains using Sonometer.
6. Bifilar suspension: Dependence of the time period on the geometry of non-parallel bifilar suspension.
7. Log Decrement.
8. Velocity of Sound using CRO.
9. Lissajous Figures (Demonstration).

References:

1. Khanna, D. and Bedi, R. 1992, *A Textbook of Sound*, Atma Ram and sons, Delhi.
2. Mathur, D. 2012, *Mechanics*, S. Chand, New Delhi.
3. Taylor, J. 2005, *Classical Mechanics,* University Science Books, USA
4. Subrahmanyam, N. and Lal, B. 1994, Waves and Oscillation, Vikas Publishing House, Noida

Additional References:

1. French, AP 2003, Vibration and Waves, CBS Publisher, India.
2. Halliday, D., Resnick, R. and Walker, J. 2003, Fundamentals of Physics, 6th edition, John Wiley and Sons, USA.
3. Pain, J. 2005, *The Physics of Vibration and Waves,* 6th Edition, Wiley.

Web References:

1. https://nptel.ac.in/courses/115/106/115106119/
2. https://nptel.ac.in/courses/115/106/115106090/
3. https://ocw.mit.edu/courses/physics/8-03sc-physics-iii-vibrations-and-waves-fall-2016/part-i-mechanical-vibrations-and-waves/
4. http://galileo.phys.virginia.edu/classes/152.mf1i.spring02/OscWavesIndex.htm
5. http://www.qrg.northwestern.edu/projects/vss/docs/communications/3-what-is-the-doppler-effect.html

Course Title : **Introduction to Astronomy and Astrophysics**

Course Code : **PHY-E17**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives : The course aims to introduce the students to the Exciting World of Extra-galactic Universe.

Course Outcomes : At the end of the course, students will be able:

CO1 : Understand the various Extra-galactic objects.
CO2 : Understand the construction, working and mounting of modern telescopes.
CO3 : Understand co-ordinate system of Celestial Objects.
CO4 : Understand types of stars and their life cycle.

Theory:

UNIT I: Fundamentals of Astronomy and Astronomical Instruments [20 h]

1. **Fundamentals of Astronomy: [10 h]**

Introduction: Components of the Universe; Stars, Planets, Asteroids, Meteors, Comets, Galaxies. Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Kepler's laws, black body radiation and curves, Doppler effect.

[Ref#1: chapter1: 1.1-1.5, chapter 3: 3.1- 3.4]

2. **Astronomical Instruments: [10 h]**

Optical telescopes, mounts, light gathering power, magnification, resolution. Spectroscopes, CCD camera, photometer, filters Radio telescopes, interferometry UV, IR, X-ray and Gamma ray telescopes. Modern telescopes: HST, Chandra.

[Ref#1: chapter19: 19.1-19.5, chapter20: 20.1-20.5]

UNIT II: Star and Star Systems and Galaxies, Dark Matter and Dark Energy [15 h]

3. **Star and Star Systems [8 h]**

Stars life cycle, Neutron stars, black holes, white dwarf, Chandrasekhar limit. Spectral classification of stars, O,B,A,F,G,K,M. Sytem of stars: Binaries / Cepheids / RR Lyrae, HR diagram, sun and solar system.

[Ref#1: chapter5: 5.1-5.7, chapter12:12.3, 12.4]

4. **Galaxies, Dark Matter and Dark Energy [7 h]**

Galaxies, classification of galaxies, Hubble's tuning fork diagram, Open and Globular clusters,

ISM.

[Ref#1: chapter16: 16.4, chapter 17:17.1-17.4]

UNIT III: Observational Astronomy [10 h]

5. **Observational Astronomy [10 h]**

Co-ordinate system, Celestial hemisphere, Concept of time, Magnitudes: apparent and absolute, constellations. Star dial, Observation of Sun, Eclipses, Moon, planets, meteor showers, transits, occultation's.

[Ref#1: chapter2; 2.1-2., Ref#2; chapter1: 1.1-1.4]

Experiments: (Minimum six)

1. Resolving power of telescope.
2. Study of scattering of light (Diameter of Lycopodium powder).
3. Study of Diffraction using plane grating.
4. To find radius of curvature of a convex lens using optical lever.
5. Measurement of the solar constant.
6. To obtain proper motion of Barnard's star using Aladin.

7. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
8. To determine the elements in sun using Fraunhofer spectra.
9. To estimate Astronomical Unit using Venus transit data by parallax method.
10. Data analysis technique using virtual observatory.
11. Determine the period of revolution of sun using virtual laboratory.

References:

1. Abhyankar K.D., 2001, *Astrophysics - Stars and Galaxies*, Tata McGraw Hill Pub.
2. Shu F., 1981, *Physical Universe-An Introduction to Astronomy*,University Science Books, U.S.

Additional References:

1. Roy A.E. and Clarke D., 1989, *Astronomy structure of the Universe*, Adam Hilger Pub.
2. Glasstone S., 1965, *Source book on theSpace Sciences*, Van Nostrand Reinhold Inc.,U.S
3. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics with Elements of Cosmology*, Narosa Pub.
4. Narlikar J.V.,1976, *Structure of the Universe*, Oxford Paperbacks.
5. Badyanath and Basu., 2010, *An Introduction to Astrophysics*, 2^{nd} Edition, Prentice Hall India Learning Private Limited

Web References:

1. https://nptel.ac.in/courses/115105046/
2. http://academics.smcvt.edu/abrizard/astronomy/Astronomy_Notes.pdf
3. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/
4. http://spiff.rit.edu/classes/phys445/phys445.html
5. https://science.nasa.gov/astrophysics/focus-areas/what-are-galaxies

Course Title : Instrumentation

Course Code : PHY-E8

Marks : 75 (Theory) + 25 (Practical)

Credit : 3 (Theory) + 1(Practical)

Pre-requisite : Nil

Course Objectives : The objective of this course is to understand basic concepts related to the various types of measuring instruments and measuring techniques.

Course Outcomes : At the end of the course, students will be able to:

CO1 : Understand basic concepts related to the various types of measuring instruments and measuring techniques.
CO2 : Comprehend basic principles involved in measuring instruments like Ammeter, Voltmeter, Ohmmeter and Multimeters.
CO3 : Understand working and use of CROs and Signal Generators
CO4 : Understand working and usage of the various types of transducers.

Theory:

Unit-I: Indicators, Display Devices and Signal Generator [10 h]

I.1: Fundamentals of Measurement [4 h]

Introduction, Performance Characteristics, Static Characteristics, Errors in Measurements, Types of Static Error, Sources of Error, Dynamic Characteristics, Standard, Electrical Standards.

[Kalsi: Chapter 1.2 to 1.7, 1.9, 1.10]

I.2: Indicators and Display Devices [4 h]

Types of Instrument, Basic Meter Movement: PMMC Movement and Practical PMMC Movement, Classification of Displays, Use of LED and LCD as Display Devices, Segmental Displays using LEDs.

[Kalsi: Chapter 2.1, 2.2, 2.8, 2.10, 2.11, 2.12.3]

I.3. Signal Generator: [2 h]

Standard Signal Generator, AF Sine and Square Wave Generator, Function Generator.

[Kalsi: Chapter 8.4, 8.5, 8.7, 8.8]

Unit- II: Measuring Devices [20 h]

II.1: Measuring Instruments [14 h]

DC Ammeter, Multirange Ammeter, Universal Shunt, Requirements of a Shunt, Extending of Ammeter Ranges. Basic Meter as a DC Voltmeter, DC Voltmeter, Multirange Voltmeter, Extending Voltmeter Ranges, Loading, Transistor Voltmeter(TVM), FET DC Voltmeter. AC Voltmeter using Rectifiers, Multirange AC Voltmeter, AC current measurements using AC Voltmeter and a series Resistor. Ohmmeter: Series type and Shunt type, Multimeter.

Digital voltmeter: Ramp Technique, Digital Multimeters and Frequency meter (with help of Block Diagrams), Q meter.

[Kalsi: Chapter 3.1 to 3.5, 4.2 to 4.7,4.12to 4.15, 4.21, 4.22, 4.25, 5.2, 6.2,6.3,10.7 and Mottershead: Chapter 22: 22-9]

II.2: Oscilloscope [6 h]

Basic Principle, Block Diagram of Oscilloscope, Simple CRO, Vertical Amplifier, Horizontal Deflecting System, sweep generator, Delay line.

[Kalsi: Chapter 7.2.1, 7.4, 7.5, 7.5.1, 7.6, 7.7.1, 7.10]

Unit-III: Introduction to Transducers and its applications [15 h]

III.1: Transducers [15 h]

Introduction, Electrical Transducer, Selecting a Transducer, Strain Gauges, Resistance Wire Gauge, Types of Strain Gauges(Wire), Foil Strain Gauge, Semiconductor Strain Gauge, Inductive Transducer, Differential Output Transducers, Linear Variable Differential Transducers (LVDT), Capacitive Transducer, Piezo-Electric Transducer, Semiconductor Diode Temperature Sensor, Temperature Transducers: Resistance Temperature Detectors, Thermistors, Thermocouples.

[Theraja: Chapter 36.1 to 36.3, 36.12 to 36.15] [Kalsi: Chapter 13.1 to 13.3, 13.6, 13.6.1 to 13.6.4, 13.9,13.9.1, 13.9.2, 13.10, 13.11,13.13, 13.15, 13.20.7]

Experiments: **(Minimum six)**

1. Use of CRO and Function Generator (AC/DC voltage measurement, frequency measurement).
2. To measure displacement (linear and angular) using potentiometer/variable inductor/variable capacitor.
3. Construction and design of analog two ranges Voltmeter.
4. Construction and design of analog two ranges Ohmmeter.

5. Crystal Oscillator: Determination of velocity of ultrasonic waves in a liquid medium.
6. Study of strain Gauges
7. Study of LVDT (including calibration) and its use in any one application.
8. Calibration of Thermocouple
9. Thermistor as a temperature sensor.
10. Application of Pt 100 as a temperature sensor.

References:

1. Kalsi H S, Electronics Instrumentation, Tata McGraw Hill Education Pvt. Ltd. New Delhi, 3rd Edition (2010).
2. Mottershead Allen, Electronics Devices and Circuits An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi, 23rd Printing, (2000).
3. Theraja B. L., Basic Electronics (Solid State), S. Chand and Company Ltd., New Delhi, 1stMulticolour Edition (2005).

Additional References:

1. Boylestad Robert and Nashelsky Louis, Electronic Devices and Circuit Theory, Prentice-Hall of India Pvt. Ltd., New Delhi, 6th Edition (2000).

Web References:

1. https://www.jameco.com/Jameco/workshop/TechTip/working-with-seven-segment-displays.html
2. https://electronics-diy.com/Function_Generator_XR2206.php
3. https://www.electronics-tutorials.ws/io/io_1.html
4. https://www.elprocus.com/cro-cathode-ray-oscilloscope-working-and-application/
5. https://www.google.com/amp/s/analyseameter.com/2015/09/digital-multimeter-dmm-working-principle.html/amp

Course Title : **Electromagnetic Theory – II**

Course Code : **PHY-V.C-7**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Electromagnetic Theory – I (PHY-III.C-5)**

Course Objectives : To acquaint students with fundamental principles of Magnetostatics part of the Electromagnetic Theory.

Course Outcomes : At the end of this course, students would be able to:

CO1 : Calculate magnetic field induction using Biot-Savart's law and Ampere's law.

CO2 : Interpret bound currents and calculate magnetic fields in matter.

CO3 : Comprehend microscopic theory magnetism.

CO4 : Establish the link between electrostatics and magnetostatics using Maxwell's equations.

CO5: Develop the wave equation for propagation of electromagnetic waves through material media and vacuum at different angles of incidence.

Theory:

UNIT – I: Magnetostatics [15 h]

1. Magnetostatics [15 h]

Lorentz force law: Magnetic fields, Magnetic forces, Currents, Biot-Savart law: Steady currents, Magnetic fields of a steady current, Divergence and Curl of **B**: Straight-line currents, divergence and curl of **B**, applications of Ampere's law, comparison of magnetostatics and electrostatics, Magnetic vector Potential: Vector potential, magnetostatic boundary conditions, multipole expansion of the vector potential.

[Griffiths: 5.1: 5.1.1 – 5.1.3, 5.2: 5.2.1 – 5.2.2, 5.3: 5.3.1 – 5.3.4, 5.4: 5.4.1 – 5.4.3]

UNIT II: Magnetic Fiels in Matter and Microscopic Theory of Magnetism [15 h]

2. Magnetic Fields in Matter [11 h]

Magnetization: Diamagnets, paramagnets and ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization, the field of a magnetized object: Bound currents, physical interpretation of bound currents, magnetic field inside matter, The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions, Linear and nonlinear media: Magnetic susceptibility and permeability, Energy in magnetic fields.

[Griffiths: 6.1: 6.1.1 – 6.1.4, 6.2: 6.2.1 – 6.2.3, 6.3: 6.3.1 – 6.3.3, 6.4: 6.4.1 – 6.4.2, 7.2.4]

3. Microscopic Theory of Magnetism [4 h]

Molecular field inside matter, origin of diamagnetism, origin of paramagnetism, theory of ferromagnetism, ferromagnetic domains, ferrites

[Reitz: 10.1 – 10.2]

UNIT III: Maxwell's Equations and Propagation of Electromagnetic Waves [15 h]

4. Maxwell's Equations [5 h]

Generalization of Ampere's law, displacement current, Maxwell's equations and their empirical basis, electromagnetic energy, Poynting theorem.

[Reitz: 16.1 – 16.3]

5. Propagation of Electromagnetic Waves [10 h]

The wave equation, plane monochromatic waves in non-conducting media, polarization, plane monochromatic waves in conducting media, reflection and refraction at the boundary of two non-conducting media: normal incidence and oblique incidence, Brewster's angle, critical angle.

[Reitz: 16.4, 17.1, 17.2, 17.4, 18.1, 18.2]

Experiments: (Minimum Six)

1. Hysteresis by magnetometer.

2. B-H curve in a hard magnetic material and in a soft ferrite.

3. Core losses and copper losses in a transformer.

4. Measurement of mutual inductance using ballistic galvanometer.

5. Calibration of lock-in-amplifier and determination of mutual inductance.

6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method.

7. M/C using ballistic galvanometer

8. Helmholtz coils.

References:

1. Griffiths D. J., 2011, *Introduction to Electrodynamics,*3rd Ed. , Prentice Hall of India.

2. Reitz J. R., Milford F. J., Christy R. W., 1979, *Foundations of Electromagnetic Theory*,3rd Ed., Addison-Wesley Publishing Company.

Additional Reference:

Mukherji U., 2008, *Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.

Web References:

1. https://nptel.ac.in/courses/115101005/
2. https://swayam.gov.in/nd1_noc19_ph08/preview
3. https://ocw.mit.edu/courses/physics/8-07-electromagnetism-ii-fall-2012/lecture-notes/
4. https://www.feynmanlectures.caltech.edu/II_toc.html
5. http://galileo.phys.virginia.edu/classes/109N/more_stuff/Maxwell_Eq.html

Course Title	**: Solid State Physics**
Course Code	**: PHY-E9**
Marks	**: 75 (Theory) + 25 (Practical)**
Credits	**: 3 (Theory) + 1 (Practical)**
Pre-requisites	**: Quantum Mechanics (PHY-IV.C-6)**

Course Objective: This course deals with crystalline solids and is intended to provide students with basic physical concepts and mathematical tools used to describe solids. The course broadly deals with the topics related to structural aspects and the various physical properties of crystalline solids.

Course Outcomes: After completion of this course, students will be able to
CO1: Identify bonding types in crystalline solids and correlate the nature of bonding of solid to some of the physical properties associated with it.
CO2: Identify different crystal systems and determine structural parameters like unit cell of crystal lattices, translation vectors, atomic packing, crystal planes and directions with help of Miller Indices.
CO3: Derive and apply Bragg's law to determine crystal structure.
CO4: Derive and apply classical free electron theory of metals to study electrical conductivity

CO5: Derive and apply density of energy states to estimate density of free electrons, Fermi energy and mean energy of electron gas at absolute zero
CO6: Derive and apply Fermi Free electron gas model in 3 dimensions to study electrical properties of metals.
CO7: Apply Kronig-Penney Model and Bloch theory to interpret energy band structures in solids, in particular knowing effective mass and E v/s k relationship.
CO8: Differentiate materials with respect to their magnetic properties.
CO9: Apply the knowledge gained to solve problems in solid state physics using relevant mathematical tools.

Theory:

Unit-I Bonding in Solids and Crystal Structures [20 h]

I.1: Bonding in Solids [5h]

Introduction, Bonding in Solids, Cohesive energy, Ionic bonding, Calculation of Cohesive energy of ionic solids, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.

[Pillai: Ch-3.I – 3.IX, 3.XII – 3.XXIV]

I.2: Crystal Structure [11h]

Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures, Crystal structures- NaCl, diamond, CsCl, ZnS, Directions in crystals, Planes in crystals- Miller indices, Distances of Separation between Successive (*hkl*) Planes.

[Pillai: Ch-4.I – 4.VIII, 4.XIV – 4.XXII]

I.3: Diffraction of X-rays by Crystals [4h]

Introduction, Bragg's law, Bragg's X-ray Spectrometer, Powder Crystal method (Debye Scherrer method), Rotating Crystal method.

[Pillai: Ch-5.VII – 5.XI]

Unit-II Electrical Properties of Metals [20 h]

Introduction, Classical Theory of Electric Conduction, Drawbacks of Classical theory, Revision of particle in a rectangular three-dimensional box, Fermi-Dirac Statistics and Electronic distribution in Solids, Fermi distribution function, Density of energy states and Fermi energy, Mean energy of electron gas at absolute zero, Electrical conductivity from Quantum mechanical consideration, Sources of electrical resistance in metals, Thermal conductivity in metals, Joule's law, Thermionic emission, Failure of Sommerfeld's free electron model, Band theory of Solids, Brillouin Zones, Motion of electrons in one- dimensional periodic potential, Distinction between metals, insulators and semiconductors.

[Pillai: Ch-6.II – IV, 6.XIV – 6.XVIII, 6.XX – 6.XXII, 6.XXV, 6.XXIX, 6.XXXI, 6.XXXV – 6.XXXXI]

Unit-III Magnetic Materials and Magnetic Properties **[5 h]**

Introduction, Classification of magnetic materials, The quantum numbers, Origin of magnetic moment, Ferromagnetism, Ferromagnetic domains, Hysteresis, Hard and soft materials.

[Palanisamy: 8.1, 8.2, 8.3, 8.4, 8.7, 8.7.3, 8.7.5, 8.7.6]

Experiments: (Minimum Six)

1. Energy band gap of a semiconductor using a diode.
2. Energy band gap of a semiconductor using LEDs
3. Energy band gap of a thermistor.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. Fermi energy of Copper
6. Measurement of Hysteresis loss using CRO
7. Calculation of lattice constant by of Copper – X-ray diffraction pattern is given and student calculates: d-spacing, miller indices and lattice constant.
8. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap
9. Investigating crystal structure using Vesta software.

References:

1. Pillai S. O., 2018, *Solid State Physics,* 8th Multi Colour Edition, New Age International Publisher.
2. Palanisamy P. K., 2004, *Solid State Physics*, Scitech Publications (India) Pvt. Ltd.

Additional References:

1. Kittel C., 2004*, Introduction to Solid State Physics*, 8th Edition,John Wiley and Sons.
2. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.

Web References:

1. https://www.youtube.com/watch?v=RImqF8z91fU&list=PLtTPtV8SRcxi91n9Mni2xcQX4KhjX91xp
2. https://www.classcentral.com/course/swayam-introduction-to-solid-state-physics-13045
3. https://www.classcentral.com/course/swayam-solid-state-physics-14298
4. https://www.youtube.com/playlist?list=PLaNkJORnlhZnC6E3z1-i7WERkferhQDzq
5. https://www.youtube.com/playlist?list=PL0jxQTuSuktJd7Gbelcg9R0f3oYYeMbRs

Course Title : **Thermodynamics and Statistical Mechanics**

Course Code : **PHY-E10**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Heat and Thermodynamics (PHY-II.C-3)**

Course Objectives : This course will introduce kinetic theory, classical thermodynamics, probability and statistical methods.

Learning Outcome : After completion of this course, students will be able to:
CO1 : Understand basics of kinetic theory of gases and thermodynamic potentials.
CO2 : Understand Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics and its application to the classical gas, electrons in a metal and blackbody radiation
CO3 : Understand the specific heat of solids by invoking statistical mechanics.

Theory

Unit 1 : Kinetic theory of Gases and Thermodynamic Potentials. **[15 h]**

1. **Kinetic theory of Gases:** [9 h]
   Basic assumptions, Equation of State of an Ideal Gas, Collisions with a moving wall, the principle of equi-partition of energy, classical theory of specific heat capacity, specific heat capacity of a solid.
   [Sears and Salinger: 9.1, 9.2, 9.4 – 9.8]

2. **Thermodynamic Potentials** [6 h]
   The Helmholtz function and Gibbs function, Thermodynamic Potentials, Maxwell Relations.
   [Sears and Salinger: 7.1-7.3]

Unit 2: Statistical Thermodynamics and Quantum Statistics **[20 h]**

1. **Statistical Thermodynamics** [10 h]
   Phase space, Probability of distribution, The most probable distribution, Maxwell Boltzmann Statistics. Molecular speeds: mean, most probable and r. m. s. speeds. Experimental verification of Maxwell Boltzmann statistics.
   [Beiser: 15.1 – 15.5]

2. **Quantum Statistics** [10 h]

   Bose Einstein statistics, Blackbody Radiation, Rayleigh Jeans formula, Plank radiation formula, Fermi Dirac statistics.
   [Beiser: 16.1 – 16.6]

Unit III : Specific Heats of Solids **[10 h]**

1. **Lattice Vibrations and Specific Heats of Solids** [10 h]
   Thermal Vibrations: Frequencies. Thermal Vibrations: Amplitudes. Normal Modes of a Lattice. Phonons. Specific Heats of Solids. The Einstein's theory. The Debye Theory. Fermi energy, Electron energy distribution.
   [Beiser: 19.1 – 19.7, Kachhava: 2.5, 2.6. 2.13]

Experiments: (Minimum Six)

1. Specific heat of Graphite
2. Study the temperature dependence of resistivity.
3. OPAMP as a bridge amplifier and its application in temperature measurement.
4. Determination of Boltzmann constant.
5. Study of Stefan's Law.
6. Determination of Stefan's constant
7. Thermal conductivity of poor conductor by LEE's method.
8. Tutorial on Maxwell Equation and Free energy
9. Tutorial on Statistical Thermodynamics
10. Tutorial on Statistical Thermodynamics

References:

1. Beiser A., 1995, *Perspectives of modern physics*, 5th edition, McGraw hill.
2. Sears F. and Salinger G., 1998, *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, 3rd Edition, Narosa.
3. Kachhava C. M., 2003, *Solid State Physics Solid State Devices and electronics*, New Age International (P) Limited.

Additional References:

1. Garg S., Bansal R.and Ghosh C., 1993, *Thermal Physics*, Tata McGraw Hill.
2. Zemansky M. and Ditman R., 1997, Heat *and Thermodynamics*, McGraw Hill.
3. Reif F., 1965, *Fundamentals of Statistical and Thermal Physics*, Mc Graw Hill
4. Brijlal, Subrahmanyam N., 2008, *Heat thermodynamics and Statistical Physics*, S Chand Company Ltd.
5. Laud B., 2003, *Introduction to Statistical Mechanics*, New Age International.
6. Saha M. and Shrivastava B., 1965, *Treatise on heat*, The Indian Press.

Web References:

1. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
2. https://nptel.ac.in/courses/113106039/
3. https://www.youtube.com/watch?v=ef54OnrZBg4&list=PLclocfvsabE1j2OcBdWfVhzNJNnbQ3YM7
4. https://aptv.org/Education/khan/topic.php?topic=thermodynamics
5. https://www.youtube.com/watch?v=Th-LQz5bBJA

Course Title : **Electronics-II**

Course Code : **PHY-E11**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Electronics-I (PHY-E5)**

Course Objectives : This course aims at introducing students to analog and digital circuits.

Course Outcomes : At the end of this course, students will be able to:
CO1: Analyse AC circuits and apply the techniques in designing circuits.
CO2: Generate different kinds of waves using OP-Amp
CO3: Understand the basic concepts of 555 timer.
CO4: Develop the ideas of monolithic linear regulators and understand different types of voltage regulators in LM series
CO5: Apply binary operations to different digital circuits
CO6: Understand the clocked digital electronics and its applications in different types of counters

Theory

UNIT – I : [15 h]

1. **AC Models (BJT)** **[4 h]**
   Base-Biased amplifier, Emitter-Biased amplifier, Small signal operation, analyzing an amplifier.
   [Ref.# 1 Article 9.1 to 9.7]

2. **Transistor Multivibrators** **[4 h]**
   Transistor as a switch, switching times, Multivibrators – Astable, Monostable, Bistable and Schmitt Trigger.
   [Ref.# 3 Article 18.1 to 18.5]

3. **FET's and MOSFET's** **[7 h]**
   Basic structure of the JFET, Principles of operation, Characteristic curves and parameters, Common source amplifiers, Common gate amplifier,
   MOSFET: Depletion Mode and Enhancement mode, Dual-Gate MOSFET.
   FET Phase shift oscillator, FET as VVR and its applications in Attenuator, AGC and Voltmeter circuits.
   [Ref.# 1 Article 13.1 to 13.9, 14.1 to 14.5]

UNIT – II: [15 h]

4. **OPAMP Applications** **[5 h]**
   Active diode circuits, Comparator, Window comparator, Schmitt Trigger, Waveform generator –Square wave, Triangular and Ramp Generator and monostable.
   [Ref. #1 Article 22.7, 22.8]

5. **Timers** **[5 h]**
The 555 Timer, Basic concept, 555 block diagram, Monostable, Astable, Bistable, Schmitt Trigger and Voltage controlled oscillator (VCO) using 555 timer.
[Ref.# 1 Article 23.7, 23.8]

6. **Monolithic Linear Regulators** **[5 h]**
Basic type of IC regulator, Load and line regulation,LM7800 series, Current Boosters, LM - 317 or LM7812 as a voltage regulator.
[Ref#4 24.4,24.5]

UNIT – III [15 h]

7. **Digital Circuits** **[7 h]**
Binary number system, Binary to Decimal and Decimal to Binary conversion, Basic logic gates, AND, OR, NOT(realization using Diodes and Transistor), NAND, NOR as universal building blocks in logic circuits, EX-OR and Ex-NOR gates.
Boolean Algebra:De Morgan's Law's, Boolean Laws, NAND and NOR gates, Sum of Products methods and Product of Sum methods of representation of logical functions. Half adder and Full adder,
Data Processing Circuits: Multiplexer and Demultiplexer, Encoders and decoders.
[Ref. # 2 Article5.1 to 5.8.1, 6.1, and 6.2]

8. **Sequential Circuits** **[8 h]**
Basic RS FF, Clocked RS FF, JK FF, D-type and T-type FF, Master Slave Concept.
Shift Registers:Serial-in-Serial-Out, Serial-in-Parallel-out, Parallel-in-Serial-out, Parallel-in-Parallel-out Shift registers (upto 4 bits)
Counters:Applications of FF's in counters, binary ripple counter, Modulus of counter (3,5) BCD Decade Counter, Cascade BCD Decade counters.
[Ref.# 2 Article7.1 to7.9, 8.1, 8.2, 8.4]

Experiments (Minimum Six):

1. Astable Multivibrator
2. Monostable Multivibrator
3. Bistable Multivibrator
4. Schmitt Trigger
5. F.E.T Characteristics
6. IC LM 317 Voltage Regulator
7. IC 555 Timer as Astable Multivibrator and its use as Voltage Controlled Oscillator
8. IC 555 Timer as Monostable Multivibrator
9. Digital Multiplexer
10. Verification of De Morgan’s Theorems and Boolean Identities
11. NAND and NOR Gates as Universal Building Blocks
12. Binary Addition –Half Adder and Full Adder Using Gates
13. JFET as a common source amplifier.

References :

1. Malvino A.,1996, *Electronic Principles*, 5th edition,Tata McGraw Hill.
2. Jain R. P. 2003, *Digital Electronics*, 3rd edition, Tata McGraw Hill.
3. Mottershed A. 1997, *Electronics Devices and Circuits an Introduction*, PHI
4. Malvino A. and Bates D.J., 2007, *Electronic Principles*, 7th edition, Tata McGraw Hill

Additional References:

1. Malvino A. and Leach D. 1986, *Digital Principles and Applications,*4th edition Tata McGraw Hill.
2. Millman J. and Halkias C., 1972, *Integrated Electronics*, Tata McGraw Hill.
3. Millman J. and Halkais C., 1967, *Electronic Devices and Circuits,* Mc Graw Hill.
4. Mehta V.K., 2003, *Principles of Electronics,* 8th edition, S. Chand & Company.

Web References:

1. https://nptel.ac.in/courses/117/107/117107094/
2. https://www.electronics-tutorials.ws
3. https://www.electronicshub.org/
4. https://nptel.ac.in/courses/108/105/108105132/
5. https://www.khanacademy.org/science/electrical-engineering

Course Title : **Mathematical Physics**

Course Code : **PHY-E12**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Pre-requisite : **Introduction to Mathematical Physics (PHY-I.C-1)**

Course Objectives : To acquaint students with mathematical skills which are required to study various concepts of Physics.

Course Outcomes : At the end of this course, students will be able to:
CO1 : Comprehend the functions of complex variables.
CO2 : Apply mathematical techniques such as: calculus of residues to evaluate definite integrals.
CO3: Apply solutions of Legendre, Bessel and Hermite equations, Fourier transforms of different functions in solving various Physics problems.
CO3 : Able to solve higher order problems in Physics**.**

Theory:

UNIT I: Functions of a Complex Variables and Calculus of Residues [15 h]

1. **Functions of a Complex Variables [8 h]**

Introduction, complex variables and representations: algebraic operations, Argand diagram: vector representation, complex conjugate, Euler's formula, De Moivre's theorem, the n^{th} root or power of a complex number, analytic functions of a complex variable: the derivative of f(z) and analyticity, harmonic functions, contour integrals, Cauchy's integral theorem, Cauchy's integral formula.
[Harper: 3.1, 3.2: 3.2.1 – 3.2.6, 3.3: 3.3.1 – 3.3.5]

2. **Calculus of Residues** **[7 h]**

Zeroes, isolated singular points, evaluation of residues: mth order pole, simple pole, the Cauchy residue theorem, the Cauchy principal value, evaluation of some definite integrals.
[Harper: 4.1 – 4.3: 4.3.1 – 4.3.2, 4.4 – 4.6: 4.6.1-4.6.4]

UNIT II: Partial Differential Equations and Special Functions of Mathematical Physics

[15 h]

3. **Partial Differential Equations and Special Functions of Mathematical Physics [15 h]**

Introduction, Some important partial differential equations in physics, an illustration of the method of direct integration, method of seperation of variables, the Hermite polynomials: basic equations of motion in mechanics, one-dimensional linear harmonic oscillator, solution of Hermite's differential equation, Legendre and associate Legendre polynomials: spherical harmonics, the azimuthal equation, Legendre polynomials, Bessel function: introduction: solution of Bessel's equation, analysis of various solutions of Bessel's equation, characteristics of Bessel functions.
[Harper: 6.1 – 6.5: 6.5.1 – 6.5.3, 6.5.8]

UNIT III: Fourier Series and Fourier Transforms [15 h]

4. Fourier Series **[7 h]**

Introduction: The Fourier cosine and sine series, change of interval, Fourier integral, complex form of Fourier series, generalized Fourier series and Dirac-delta function, summation of the Fourier series.
[Harper: 7.1 – 7.3]

5. Fourier Transforms **[8 h]**

Introduction, theory of Fourier transforms: formal development of the complex Fourier transform, cosine and sine transforms, multiple-dimensional Fourier transforms, the transforms of derivatives, the convolution theorem, Parseval's relation, the wave packet in quantum mechanics: origin of the problem - quantization of energy, the development of a new quantum theory, a wave equation for particles - the wave packet.
[Harper: 8.1 – 8.3]

Experiments: (Minimum Six)

1. Generating and plotting Legendre Polynomials.
2. Generating and plotting Bessel function.
3. Generating and plotting Hermite Polynomials.
4. Using spherical polar co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
5. Using cylindrical co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
6. Fourier series: programme to sum:$\sum_{n=1}^{\infty}(0.2)^n$, and to evaluate Fourier co-efficients of a given periodic functions.
7. Compute the nth roots of unity for n = 2, 3, and 4.

References:

1. Harper, C., 1993*, Introduction to Mathematical Physics,* 5th Ed.*,* Prentice Hall of India,.
2. Arfken G., 2005, *Mathematical Methods for Physicists*, Elsevier.
3. Spiegel, M.R., 2004, *Fourier Analysis*, Tata McGraw-Hill.

Additional References:

1. Riley K. F., Hobson M. P., Bence S. J., 1998, *Mathematical Methods for Physics and Engineering,* Cambridge University Press
2. Boas M. L., 2013, *Mathematical Methods in Physical Sciences,* John Wiley and Sons, 3rd Ed.
3. Lipschutz S., 1974, *Schaum Outline of Theory and Problems of Complex Variables*, Mc Graw Hill.

Web References:

1. https://nptel.ac.in/courses/115106086/
2. https://www.maths.ed.ac.uk/~jmf/Teaching/MT3/ComplexAnalysis.pdf
3. https://www-thphys.physics.ox.ac.uk/people/FrancescoHautmann/ComplexVariable/s1_12_sl8.pdf
4. https://nptel.ac.in/courses/111/106/111106100/
5. https://nptel.ac.in/courses/115/105/115105097/

Course Title **: Solid State Devices**

Course Code **: PHY-E6**

Marks **: 75 (Theory) + 25 (Practical)**

Credits **: 3 (Theory) + 1(Practical)**

Pre-requisite **: Nil**

Course Objectives **:** The objectives are to provide a clear explanation of the operation of most commonly used solid state devices.

Course Outcomes **:** At the end of this course, the students will be able to:

CO1 : Comprehend the p-n junction theory and analyse the effect of heat and light on the performance of the semiconductor devices.

CO2: Understand different types of special diodes and their uses in various electronics applications.

CO3 : Understand different types of optoelectronic devices and their uses in various electronics applications.

CO4: Design, construct and study the performance of circuits based on breakdown devices.

CO5 : Corelate the theory to understand the working of these devices.

Theory:

UNIT – I: Basic Semiconductor and pn-Junction Theory and Special Diodes [15 h]

1. Basic Semiconductor and pn-Junction Theory: [10 h]

The Atom, Electron Orbit and Energy Levels, Energy Bands, Conduction in Solids, Conventional Current and Electron Flow, Bonding Forces between Atoms, Classification of Solids, Intrinsic Semiconductor, Conduction of Electrons and Holes, *p*-Type and *n*-Type Semiconductors, Effect of Heat and Light, Drift Current and Diffusion Current, The *pn*-Junction, Reverse-biased Junction, Forward-biased Junction, Temperature Effect, Mobility and Conductivity, Hall Effect and Hall Coefficient.

[Ref.1: Chapter 1 and Ref.2: Chapter 1: 1.8 and1.9]

2. Special Diodes: [5 h]

Zener Diode, Use of Zener Diode as voltage regulator and as Peak Clipper, Meter Protection, Tunneling Effect, Tunnel Diode, Tunnel Diode as Oscillator, Varactor, PIN Diode, Schottky Diode, Step Recovery Diode.

[Ref.3: Chapter 15]

UNIT II: Optoelectronic Devices and Industrial Devices [20 h]

3. Optoelectronic Devices: [8 h]

Light Units, Photomultiplier tube, Photoconductive Cell, Photovoltaic Cell, Photodiode, Solar Cell, Phototransistor, PhotoFET, Spectral response of Human eye, Light Emitting Diode(LED), Liquid Crystal Display(LCD), Optoelectronic Couplers, Laser Diode, Light Dependent Resistor (LDR).

[Ref.1: Chapter 19: 19-1 to 19-7, 19-9, 19-11, 19-12 and Ref.3: 16.1 to 16.3]

4. Industrial Devices: [12 h]

Silicon Controlled Rectifier(SCR), SCR Characteristic and Parameters, Simple applications of SCR: HWR, Battery-charging regulator and Temperature Controller, Silicon Controlled Switch (SCS), Gate Turn Off switch (GTO), Light Activated SCR (LASCR), Shockley Diode, The TRIAC and DIAC, Typical Diac-Triac Phase control circuit, The Unijunction Transistor(UJT), UJT Characteristics, UJT Parameter and Specification, UJT Relaxation Oscillator, UJT Control of SCR, Programmable Unijunction Transistor.

[Ref.1: Chapter 18: 18-1, 18-2, 18-4, 18-6 to 18-11; Ref.4: Chapter 21: 21.6 to 21.10 and Ref.5: Chapter 28: 28-4]

UNIT – III: Field Effect Transistors [10 h]

5. Field Effect Transistors: [10 h]

Advantage and Disadvantage of The FET, Basic Construction of JFET, Characteristics curves of The JFET, Principle of operation of The JFET, Effect of V_{DS} on Channel Conductivity, Channel Ohmic Region and Pinch-Off Region, Characteristic Parameters of The FET, Effect of Temperature on FET

Parameters, The MOSFET, The Depletion MOSFET, The Enhancement MOSFET, The difference between JFETs and MOSFETs, Dual Gate MOSFET, FET used in Phase-Shift Oscillator Circuit, Applications of FET in its Channel Ohmic Region, FET as a VVR in Voltage controlled Attenuator and in an Automatic Gain Controlled Circuit, Field-Effect Diode and its use as CRD, Power MOSFETs.

[Ref.5: Chapter 21: 21-1 to 21-8, Chapter 22: 22-1 to 22-5, 22-9, 22-10;

Ref.1: Chapter 8: 8-9]

Experiments: **(Minimum six)**

1. Energy Gap of a Semiconductor
2. Energy Gap of a LED.
3. Zener Diode Characteristics and Voltage regulation
4. LDR Characteristics
5. LED VI Characteristics
6. Phototransistor
7. SCR characteristics and gate controlled ac half wave rectifier
8. UJT Characteristics and its use in relaxation oscillator
9. FET Characteristics
10. Solar Cell.
11. SCR, Diac, Triac Characteristics.

References:

1. Bell David A., Electronics Devices and Circuits, Prentice-Hall of India Pvt. Ltd., New Delhi, 3rd Edition (2000).
2. Singh Kamal and Singh S. P., Solid State Devices and Electronics, S. Chand & Company Ltd., New Delhi, 1st Edition (2007).
3. Theraja B. L., Basic Electronics (Solid State), S. Chand and Company Ltd., New Delhi, 1stMulticolour Edition (2005).
4. Boylestad Robert and Nashelsky Louis, Electronic Devices and Circuit Theory, Prentice-Hall of India Pvt. Ltd., New Delhi, 6th Edition (2000).
5. Mottershead Allen, Electronics Devices and Circuits An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi, 23rd Printing, (2000).

Web References:

1. https://nptel.ac.in/courses/117106091/
2. https://www.elprocus.com/types-of-diodes-and-applications/
3. https://www.electronicshub.org/types-of-diodes/
4. https://www.electronicshub.org/thyristor-basics/
5. https://gradeup.co/field-effect-transistor-study-notes-i-96d9d1d0-79ad-11e7-bf36-f08a68dca14c

MATRIX -1
MAPPING COURSES/ACTIVITIES TO PROGRAMME LEARNING OUTCOME
PROGRAMME: B.Sc. in Physics

(use ☑ if linked, ☒ if not linked)

PLOS / Course /Activity		PLO-1: Use of Technology, Problem Analysis and Solutions	PLO-2: Environment Sustainability & Ethics	PLO -3: Individual and Team work, Communication & Life Skills	PLO-4: Research Aptitude & Social responsibility	PLO-5: Strengthen the understanding of basic concepts of Physics and impart required mathematical skills	PLO-6 Provide a strong base in Experimental Physics to pursue higher studies/research in Experimental Physics.	PLO-7: Provide a sound foundation in Theoretical Physics to pursue higher studies/research in Theoretical Physics	PLO-8: Developing analytical thinking and logical reasoning	PLO-9: Enhancing problem solving skills	PLO-10: Promote self-learning, self-confidence, communication skills and team work.	PLO-11: Enhancing employability through skill enhancement courses
Courses Component A	PHY-I.C-1	√	x	√	x	√	√	√	√	√	x	x
	PHY-I.C-2	√	x	√	x	√	x	√	√	√	x	x
	PHY-II.C-3	√	x	√	x	√	x	√	√	√	x	x
	PHY-II.C-4	√	x	√	x	√	√	√	√	√	x	x
	PHY-III.C-5	√	x	√	x	√	x	√	√	√	x	x
	PHY-E1	√	x	√	x	√	√	√	√	√	√	x
	PHY-E2	√	x	√	x	√	x	√	√	√	x	x
	PHY-E3	√	x	√	x	√	x	√	√	√	√	x
	PHY-IV.C-6	√	x	√	x	√	x	√	√	√	x	x
	PHY-E5	√	x	x	x	√	x	x	√	√	x	x
	PHY-E18	√	x	√	x	√	√	x	√	√	√	x
	PHY-E4	√	x	√	x	√	x	√	√	√	√	x
	PHY-IV.C-7	√	x	√	x	√	x	√	√	√	x	x
	PHY-E9	√	x	√	x	√	√	√	√	√	√	x
	PHY-E10	√	x	√	x	√	x	√	√	√	x	x
	PHY-E11	√	x	√	x	√	x	√	√	√	x	x
	PHY-IV.C-8	√	x	√	x	√	x	√	√	√	x	x
	PHY-E13	√	x	√	x	√	x	√	√	√	x	x
	PHY-E14	√	x	√	x	√	√	√	√	√	√	x
	PHY-E15	√	x	√	x	√	x	√	√	√	x	x
Component D	Internship	√	√	√	√	√	√	√	√	√	√	√
Activities of the department	*Workshops*	√	x	√	√	√	√	√	√	√	√	x
	Newsletter	x	√	x	x	x	x	x	x	x	√	x
	Physics Day	√	x	√	x	x	x	x	x	x	√	x
	NGPE	√	x	√	x	√	x	x	√	√	x	x
	subject talks	√	x	√	√	√	√	√	√	√	√	x

MATRIX -2 *(Course-wise)*

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-I.C-1

Course Title: Introduction to Mathematical Physics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	√	√	X	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	√	X	X
CO4	√	X	X	X	√	X	√	√	√	X	X
CO5	√	X	X	X	√	X	√	√	√	X	X
CO6	√	X	X	X	√	X	√	√	√	√	X
CO7	√	X	X	X	√	X	X	X	X	X	X
CO8	√	X	X	X	√	√	√	√	√	√	X

MATRIX -2 *(Course-wise)*

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-I.C-2

Course Title: Mechanics - I

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	√	X	√	√	√	√	√	√	X
CO2	√	X	√	X	√	√	√	√	√	√	X
CO3	√	X	√	X	√	X	√	√	√	√	X
CO4	√	X	√	X	√	√	√	√	√	√	X
CO5	√	X	√	X	√	X	√	√	√	√	X

MATRIX -2 *(Course-wise)*

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-II.C-3

Course Title: Heat and Thermodynamics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	X	√	√	X	X
CO2	X	X	X	X	√	√	X	X	X	X	X
CO3	X	X	X	X	√	X	√	√	X	X	X
CO4	X	X	X	X	√	X	√	√	X	X	X
CO5	√	X	X	X	√	X	√	√	X	X	X
CO6	X	X	X	X	X	X	X	√	√	X	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-II.C-4

Course Title: Electricity and Magnetism

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	√	√	√	√	√	√	√	√	√
CO2	√	X	√	√	√	√	√	√	√	√	√
CO3	√	X	√	√	√	√	√	√	√	√	√
CO4	√	X	√	√	√	√	√	√	√	√	√

MATRIX -2 *(Course-wise)*
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Core)*
Course Code: PHY-III.C-5
Course Title: Electromagnetic Theory - I
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	√	√	X	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	√	X	X
CO4	√	X	X	X	√	X	√	√	√	X	X
CO5	√	X	X	X	√	X	X	√	X	X	X

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E1
Course Title: Optics
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	x	√	x	√	√	√	√	√	√	√
CO2	√	x	√	x	√	√	√	√	√	√	√
CO3	√	x	√	x	√	√	√	√	√	√	√
CO4	√	x	√	x	√	√	√	√	√	√	√
CO5	√	x	√	x	√	√	√	√	√	√	√
CO6	√	x	√	x	√	√	√	√	√	√	√
CO7	√	x	√	x	√	√	√	√	√	√	√
CO8	√	x	√	x	√	√	√	√	√	√	√
CO9	√	x	√	x	√	√	√	√	√	√	√

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E2

Course Title: Modern Physics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	X	√	√	X	X
CO2	√	X	X	X	√	√	√	√	√	X	X
CO3	√	X	X	X	√	√	√	√	√	X	X
CO4	√	X	X	X	√	X	√	√	√	X	X
CO5	√	X	X	X	√	√	X	√	X	X	X
CO6	√	X	X	X	√	√	√	√	X	X	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E3

Course Title: Oscillations, Waves and Sound

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	√	X	√	X	√	√	√	√	X
CO2	√	X	X	X	√	X	√	√	√	√	X
CO3	√	X	√	X	√	√	√	√	√	√	X
CO4	√	X	√	X	√	X	√	√	√	√	X
CO5	√	X	√	X	√	X	X	√	√	√	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-IV.C-6

Course Title: Quantum Mechanics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	X	√	√	X	X
CO2	√	X	X	X	√	X	X	√	√	X	X
CO3	√	X	X	X	√	X	X	√		X	X
CO4	√	X	X	X	√	X	X	√	√	√	X
CO5	√	X	X	X	√	X	X	√	√	√	X
CO6	√	X	X	X	√	X	X	√	√	√	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E5

Course Title: Electronics – I

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	x	x	x	√	√	√	√	√	x	x
CO2	√	x	x	x	√	√	x	√	√	x	x
CO3	√	x	x	x	√	√	x	√	√	x	x
CO4	√	x	x	x	√	√	x	√	√	x	x

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E18
Course Title: Introduction to Error Analysis
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	√	X	√	√	X	√	√	√	X
CO2	√	X	√	X	√	√	X	√	√	√	X
CO3	√	X	√	X	√	√	X	√	√	√	X
CO4	√	X	√	X	√	√	X	√	√	√	X
CO5	√	X	X	X	√	√	√	√	√	√	X
CO6	√	X	√	X	√	√	X	√	√	√	X

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E4
Course Title: Properties of Matter and Acoustics
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	√	√	√	√	√	X
CO2	X	X	X	X	√	√	X	√	√	√	X
CO3	√	X	X	X	√	√	√	√	√	√	X

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Core)*
Course Code: PHY-V.C-7
Course Title: Electromagnetic theory - II
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	√	√	X	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	X	X	X
CO4	√	X	X	X	√	X	√	√	X	X	X
CO5	√	X	X	X	√	X	√	√	√	X	X

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E9
Course Title: Solid State Physics
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	x	√	x	√	√	√	√	√	√	√
CO2	√	x	√	x	√	√	√	√	√	√	√
CO3	√	x	√	x	√	√	√	√	√	√	√
CO4	√	x	√	x	√	√	√	√	√	√	√
CO5	√	x	√	x	√	√	√	√	√	√	√
CO6	√	x	√	x	√	√	√	√	√	√	√
CO7	√	x	√	x	√	√	√	√	√	√	√
CO8	√	x	√	x	√	√	√	√	√	√	√
CO9	√	x	√	x	√	√	√	√	√	√	√

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E10

Course Title: Thermodynamics and Statistical Physics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	√	√	√	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	√	X	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E11

Course Title: Electronics - II

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	√	X	√	√	X	√	√	√	√
CO2	√	X	√	X	√	√	X	√	√	√	√
CO3	√	X	√	X	√	√	X	√	√	√	√
CO4	√	X	√	X	√	√	X	√	√	√	√
CO5	√	X	√	X	√	√	X	√	√	√	√
CO6	√	X	√	X	√	√	X	√	√	√	√

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Core)*

Course Code: PHY-VI.C-8

Course Title: Atomic and Molecular Physics

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	√	√	X	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	√	X	X
CO4	√	X	X	X	√	X	√	√	√	X	X
CO5	√	X	X	X	√	X	√	√	√	X	X
CO6	√	X	X	X	√	X	√	√	√	√	X

MATRIX -2 (Course-wise)

MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES

Programme: BSc Physics

Type of Course: *(Elective)*

Course Code: PHY-E13

Course Title: Mechanics - II

(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	X	X	X	√	X	√	X	√	X	X
CO2	√	X	X	X	√	X	√	√	√	X	X
CO3	√	X	X	X	√	X	√	√	√	X	X
CO4	√	X	X	X	√	X	√	√	X	X	X
CO5	√	X	X	X	√	X	√	√	√	X	X
CO6	X	X	X	X	√	X	√	√	X	X	X
CO7	√	X	X	X	√	X	√	√	√	X	X

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E14
Course Title: Nuclear and Elementary Particle Physics
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	x	√	x	√	√	√	√	√	√	√
CO2	√	x	√	x	√	√	√	√	√	√	√
CO3	√	x	√	x	√	√	√	√	√	√	√
CO4	√	x	√	x	√	√	√	√	√	√	√
CO5	√	x	√	x	√	√	√	√	√	√	√
CO6	√	x	√	x	√	√	√	√	√	√	√

MATRIX -2 (Course-wise)
MAPPING OF PROGRAMME LEARNING OUTCOME TO COURSE LEARNING OUTCOMES
Programme: BSc Physics
Type of Course: *(Elective)*
Course Code: PHY-E15
Course Title: Introduction to Special Theory of Relativity
(use √ if linked, X if not linked)

PLOs / CLOs	1	2	3	4	5	6	7	8	9	10	11
CO1	√	x	√	√	√	x	X	√	√	√	√
CO2	√	x	√	√	√	x	X	√	√	√	√
CO3	√	x	√	√	√	x	X	√	√	√	√
CO4	√	x	√	√	√	x	X	√	√	√	√