ST. JOSEPH'S COLLEGE (AUTONOMOUS)
JAKHAMA-NAGALAND

SYLLABUS
(Outcome Based Education)

CURRICULUM AND CREDIT FRAMEWORK
FOR
UNDERGRADUATE PROGRAMMES (NEP-2020)

DEPARTMENT OF PHYSICS

With effect from the Academic Year 2023-2024
(1st to 4th FYUGP)

PREAMBLE

Physics is the most basic of the natural sciences. It is concerned with understanding the world on all scales of length, time, and energy. The methods of physics are diverse, but they share a common objective to develop and refine fundamental models that quantitatively explain observations and the results of experiments. The discoveries of physics, exemplified by the laws of physics, rank among the most important achievements of human inquiry, and have an enormous impact on human culture and civilization. The story of physics has been of people who thought outside the box. From Galileo and Newton in the 1600s to Einstein and Feynman in the 20th century, the progress of science in answering fundamental questions about the Nature is rooted in a different way of approaching things. A scientific way to test the validity of a physical theory, using a methodical approach to compare the implications of the theory in question with the associated conclusions drawn from experiments and observations conducted to test it. The B.Sc. Programme in Physics is a rigorous study program at Undergraduate level covering both the depth and breadth of all relevant areas, and provides substantial research training. It is designed to impart a thorough knowledge of the fundamental principles of the several branches of physics, as mathematically and experimentally demonstrated; and also to execute with their own hands various experiments to have hands-on experience with the tools and methods of physics, not simply with the concepts. The program aims to train future generations of physicists with specialization in the frontier areas of research.

INTRODUCTION

The NEP-2020 presents a unique opportunity to revolutionize the higher education system in India by shifting the focus from teachers to students. This policy promotes Outcome-Based Education, where the desired graduate attributes serve as the foundation for designing programs, courses, and supplementary activities that enable students to achieve the desired learning outcomes. The curriculum framework in Physics aims to provide a strong foundation in the subject and equip students with valuable cognitive abilities and skills necessary for success in diverse professional careers in a developing and knowledge-based society. The framework adheres to globally competitive standards of knowledge and skills in Physics while emphasizing the development of scientific orientation, an enquiring spirit, problem-solving skills, and values that promote rational and critical thinking. The program's structure is multidisciplinary, allowing students to explore the intersections between physics and other fields of study. This approach provides students with a broader perspective and helps them understand the interconnectedness of various areas of knowledge. The program also aims to promote students' personal and professional growth by motivating them to engage in co-curricular and extracurricular activities, which will help them develop essential skills like leadership, teamwork, and communication. The program's syllabus is designed to promote critical thinking, develop problem-solving abilities, and encourage creativity. It includes laboratory work and practical exercises that give students the opportunity to apply theoretical concepts to real-world problems and enhance their scientific skills.The program's multidisciplinary and holistic approach equips students with the skills and knowledge necessary for success in a rapidly changing world. Its commitment to social responsibility and sustainable development reflects its mission to produce not only accomplished physicists but also responsible and ethical global citizens. The NEP 2020 promotes multidisciplinary education in the undergraduate program that integrates social sciences, arts and humanities with science, technology, engineering and mathematics. For holistic development of individuals it requires to develop all capacities of human beings including intellectual, social, physical, emotional and moral behavior. Individuals should be acquainted in fields across the arts, humanities, languages, sciences and social sciences; professional, technical and vocational fields; soft skills, such as communication, discussion and debate etc.. In order to develop such holistic and multidisciplinary education, the curriculum and credit framework in Physics are designed accordingly. The course in Physics consists of six different types of courses- (i) Core courses, (ii) Minor courses, (iii) Multidisciplinary courses (iv) Ability enhancement courses (AEC), (v) Value added courses (VAC) and (vi) Skill enhancement courses.

PROGRAMME LEARNING OUTCOMES

The NEP 2020 has placed significant emphasis on outcome-based education, which highlights the importance of specific learning outcomes for each course. For Physics ,programme learning outcomes include:

PO 1:Knowledge and Comprehension: Students will be able to demonstrate a thorough understanding of fundamental principles and concepts of physics, including classical mechanics, electromagnetism, thermodynamics, quantum mechanics, and statistical mechanics.

PO 2:Analytical and Problem-Solving Abilities: Students will have the ability to apply their knowledge of physics to analyze and resolve problems in various settings, using appropriate mathematical tools, experimental methods, and computational techniques.

PO 3:Research and Inquiry Skills: Students will possess the ability to participate in research and inquiry based activities, such as creating and executing experiments, collecting and evaluating data, and communicating their findings in a clear and effective manner.

PO 4:Communication and Presentation Skills: Students will be able to express their ideas and discoveries effectively through both written and oral presentations, utilizing suitable scientific language and tools.

PO 6:Ethics and Values: Students will possess knowledge of the ethical and social implications of their work and demonstrate a dedication to the ethical and responsible conduct of research and practice.

PO 7: Interdisciplinary and Multidisciplinary Learning: Students will be capable of combining their understanding and skills with other disciplines and participating in multidisciplinary research and innovation.

These programme learning outcomes have been formulated to ensure that students acquire a strong basis in physics while also developing a range of transferable skills and abilities that will equip them for a diverse range of professions and further studies. By implementing an outcome-based approach and emphasizing learner-centric pedagogies, students will be able to meet these objectives and satisfy the ever-changing job market demands.

Programme Structure

Semester	Major or Core Paper (4 credits each)	Inter-disciplinary Minor Paper (4 credits each)	Multidisciplinary Course (4 credits each)	Skill Enhancement courses (SEC) OR Internship/ Apprenticeship/Project/Community Outreach (2 credits each)	Ability enhancement Courses (AEC) (2 credits each)	Value Added Course (VAC) (2 credits each)	Total Credits
I	PHC 1.1: Mathematical Physics-1 (3) PHC 1.1(P): Mathematical Physics-1 (1) PHC 1.2: Mechanics (3) PHC 1.2(P): Mechanics (1)	PHM 1: Mechanics (3) PHM 1(P): Mechanics (1)	MDC - 1: Environmental Studies	PHS 1: Renewable Energy and Energy Harvesting (2)	AEC- 1:English Communication (2)	VAC-1: Constitutional Values(2)	22
II	PHC 2.1: Electricity and Magnetism (3) PHC 2.1(P): Electricity and Magnetism (1) PHC 2.2: Waves and Optics(3) PHC 2.2(P): Waves and Optics (1)	PHM 2: Electricity and Magnetism (3) PHM 2(P): Electricity and Magnetism (1)	MDC-2: Programming using Python	PHS 2 : Basic Instrumentation Skills (2)	AEC-2:Basic Functional English(2)	VAC-2: Consumer Rights(2)	22
Exit option with Undergraduate Certificate (44 Credits)							**44**
III	PHC 3.1: Mathematical Physics-11 (3) PHC 3.1(P): Mathematical Physics-11 (1) PHC 3.2: Analog Systems & Applications(3) PHC 3.2(P): Analog Systems & Applications (1) PHC 3.3: Thermal Physics (3) PHC 3.3(P): Thermal Physics (1)	PHM 3: Thermal Physics & Statistical Mechanics (3) PHM 3(P): Thermal Physics & Statistical Mechanics (1)	MDC-3: Intellectual Property Rights	PHS 3: Radiation Safety (2)			22
IV	PHC 4.1: Mathematical Physics-III (3) PHC 4.1(P): Mathematical Physics-III (1) PHC 4.2: Elements of Modern Physics (3) PHC 4.2(P): Elements of Modern Physics (1) PHC 4.3: Digital Systems and Application (3) PHC 4.3(P): Digital Systems and Application (1)	PHM 4: Elements of Modern Physics(3) PHM 4(P): Elements of Modern Physics (1)		PHS 4: Electrical Circuit and Network (2)	AEC-3:Poetry, Prose and Short Stories (2)	VAC-3 :Work Ethics(2)	22
Exit option with Undergraduate Diploma (88 Credits)							**88**
V	PHC 5.1: Quantum Mechanics-I (3) PHC 5.1(P): Quantum Mechanics-I (1) PHC 5.2: Classical Dynamics (4) PHC 5.3:Solid state Physics (3) PHC 5.3(P): Solid state Physics (1)	PHM 5: Solid state Physics (3) PHM 5 (P): Solid state Physics (1)		PHS 5: Basic Workshop Skills (2)	AEC-4 : Novel and Drama (2)	VAC- 4:India through the ages(2)	22
VI	PHC 6.1: Quantum Mechanics-II(4) PHC 6.2: Nuclear and Particle Physics (4) PHC 6.3: Electromagnetic Theory(3) PHC 6.3(P): Electromagnetic Theory (1) PHC 6.4: Statistical Mechanics (3) PHC 6.4 (P): Statistical Mechanics (1)	PHM 6: Nuclear and Particle Physics (4)		PHS 6 : Weather forecasting (2)			22
Exit option with Bachelor of Science, B.Sc Physics (132 Credits)-UG Degree							**132**

Semester	Major or Core Paper (4 credits each)	Inter-disciplinary Minor Paper (4 credits each)	Multidisciplinary Course (4 credits each)	Skill Enhancement courses (SEC) OR Internship/ Apprenticeship/Project/Community Outreach (2 credits each)	Research Project/ Dissertation (12 Credits) OR 3 Theory Papers (12 Credits)	Total Credits
VII	PHC 7.1:Astronomy and Astrophysics(4) PHC 7.2: Material Science & Nano Technology(4) RM: Research Methodology(4)	PHM 7: Digital, Analog & Instrumentation(3) PHM 7(P): Digital, Analog & Instrumentation (1) PHM 8: Bio Physics (4)			Research Project/ Dissertation will start	20
VIII	PHC 8.1: Photonics (3) PHC 8.1(P): Photonics (1)	PHM 9:Earth Science(4)			Research Project/Dissertation in major(12) **OR** PHM 10: Astrobiology and Extraterrestrial life (4) PHC 8.2: Bio Physics (4) PHC 8.3: Atmospheric Physics (3) PHC 8.3(P): Atmospheric Physics (1)	20
Bachelor of Science, B.Sc Physics (Honours)with Research (172 Credits)						**172**

DISCIPLINE SPECIFIC COURSES (DSC)

SEMESTER	COURSES OPTED	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	DSC-1 DSC-1 (P)	PHC 1.1 PHC 1.1(P)	Mathematical Physics-I Mathematical Physics-I	3 1
	DSC-2 DSC-2 (P)	PHC 1.2 PHC 1.2 (P)	Mechanics Mechanics	3 1
II	DSC-3 DSC-3 (P)	PHC 2.1 PHC 2.1 (P)	Electricity and Magnetism Electricity and Magnetism	3 1
	DSC-4 DSC-4 (P)	PHC 2.2 PHC 2.2 (P)	Waves and Optics Waves and Optics	3 1
III	DSC-5 DSC-5(P)	PHC 3.1 PHC 3.1 (P)	Mathematical Physics-II Mathematical Physics-II	3 1
	DSC-6 DSC-6(P)	PHC 3.2 PHC 3.2 (P)	Analog Systems and Application Analog Systems and Application	3 1
	DSC-7 DSC-7(P)	PHC 3.3 PHC 3.3 (P)	Thermal Physics Thermal Physics	3 1
IV	DSC-8 DSC-8(P)	PHC 4.1 PHC 4.1 (P)	Mathematical Physics-III Mathematical Physics-III	3 1
	DSC-9 DSC-9(P)	PHC 4.2 PHC 4.2 (P)	Elements of Modern Physics Elements of Modern Physics	3 1
	DSC-10 DSC-10(P)	PHC 4.3 PHC 4.3 (P)	Digital Systems and Application Digital Systems and Application	3 1
V	DSC-11 DSC-11(P)	PHC 5.1 PHC 5.1 (P)	Quantum Mechanics-I Quantum Mechanics-I	3 1
	DSC-12	PHC 5.2	Classical Dynamics	4
	DSC-13 DSC-13(P)	PHC 5.3 PHC 5.3 (P)	Solid state Physics Solid state Physics	3 1
VI	DSC-14	PHC 6.1	Quantum Mechanics-II	4
	DSC-15	PHC 6.2	Nuclear & Particle Physics	4
	DSC-16 DSC-16(P)	PHC 6.3 PHC 6.3(P)	Electromagnetic Theory Electromagnetic Theory	3 1
	DSC-17 DSC-17(P)	PHC 6.4 PHC 6.4 (P)	Statistical Mechanics Statistical Mechanics	3 1
VII	DSC-18	PHC 7.1	Astronomy and Astrophysics	4
	DSC-19	PHC 7.2	Material Science & Nano Technology	4
	RM	RM	Research Methodology	4

SEMESTER	COURSES OPTED	PAPER CODE	TITLE OF THE PAPER	CREDITS
VIII	DSC-20 DSC-20(P)	PHC 8.1 PHC 8.1(P)	Photonics Photonics	3 1
			3 Theory Papers in lieu of Research Project/Dissertation (For Honors Students not undertaking Research Projects)	
	DSC-21	PHC 8.2	Bio Physics	4
	DSC-22 DSC-22(P)	PHC 8.3 PHC 8.3(P)	Atmospheric Physics Atmospheric Physics	3 1

MINOR PAPERS

SEMESTER	COURSES OPTED	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	IDM-1 IDM-1(P)	PHM 1 PHM 1(P)	Mechanics Mechanics	3 1
II	IDM-2 IDM-2(P)	PHM 2 PHM 2 (P)	Electricity and Magnetism Electricity and Magnetism	3 1
III	IDM-3 IDM-3(P)	PHM 3 PHM 3 (P)	Thermal Physics & Statistical Mechanics Thermal Physics & Statistical Mechanics	3 1
IV	IDM-4 IDM-4(P)	PHM 4 PHM 4 (P)	Elements of Modern Physics Elements of Modern Physics	3 1
V	IDM-5 IDM-5(P)	PHM 5 PHM 5 (P)	Solid state Physics Solid state Physics	3 1
VI	IDM-6	PHM 6	Nuclear and Particle Physics	4
VII	IDM-7 IDM-7(P)	PHM 7 PHM 7 (P)	Digital, Analog & Instrumentation Digital, Analog & Instrumentation	3 1
	IDM-8	PHM 8	Bio Physics	4
VIII	IDM-9	PHM 9	Earth Science	4
	IDM-10	PHM 10	Astrobiology and Extraterrestrial life	4

MULTIDISCIPLINARY/INTRODUCTORY COURSES

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	MDC-1	Environmental Studies	4
II	MDC-2	Programming using Python	4
III	MDC-3	Intellectual Property Rights (IPR)	4

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER	COURSES OPTED	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	SEC-1	PHS 1	Renewable Energy and Energy Harvesting	2
II	SEC-2	PHS 2	Basic Instrumentation Skills	2
III	SEC-3	PHS 3	Radiation Safety	2
IV	SEC-4	PHS 4	Electrical Circuit and Network	2
V	SEC-5	PHS 5	Basic Workshop Skill	2
VI	SEC-6	PHS 6	Weather Forecasting	2

ABILITY ENHANCEMENT COURSES

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	AEC-1	English Communication	2
II	AEC-2	Basic Functional English	2
III	AEC-3	Poetry, Prose and Short Stories	2
IV	AEC-4	Novel and Drama	2

VALUE ADDED COURSES

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	VAC-1	Constitutional Values	2
II	VAC-2	Consumer Rights	2
III	VAC-3	Work Ethics	2
IV	VAC-4	India through the ages	2

DISCIPLINE SPECIFIC CORE PAPERS

Semester-I

Semester	I
Paper Code	PHC 1.1
Paper Title	Mathematical Physics –I
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper**Mathematical Physics-1**:

CO 1:	To make the students understand the idea of Vector Analysis and Vector Differentiation
CO 2:	To enable the students understand about First order and second order differential equations
CO 3:	To make the students well versed in Vector Integration
CO 4:	To create an understanding on Orthogonal Curvilinear Coordinates
CO 5:	To introduce the basic idea on Dirac delta functions and probability

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Vector Analysis and Vector Differentiation**	Vector Analysis: Properties of vectors under rotation. Scalar product and its invariance under rotation. Vector product, scalar triple product and their interpretations in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its	CSO 1.1: To define vectors(K) CSO 1.2: To explain the properties of vectors under rotation and calculate problems related to it (U+A) CSO 1.3: To define and explain scalar and vector products variance and invariance under rotation (K+U) CSO 1.4: To work out problems under scalar product and vector product and its variance and invariance(A) CSO 1.5: To explain about Scalar field and Vector field (U) CSO 1.6: To define and explain directional and normal derivatives (K+U) CSO 1.7: To work out Problems based on directional and normal derivatives (A)	13	25	Not to be filled-in

	geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.	CSO 1.8: To define and explain gradient of a scalar field and its geometrical interpretation. (K+U) CSO 1.9: To solve problems based on gradient of a scalar field (A) CSO 1.10: To define and explain Divergence and Curl of a vector field. (K+U) CSO 1.11: To work out problems based on Divergence and Curl of a vector field (A) CSO 1.12: To define and explain Del and Laplacian operators and their differences (K+U) CSO 1.13: To solve problems based on Del and Laplacian operators (A)			
UNIT 2 **First order and second order differential equations**	First order differential equations, Integrating Factor. Homogenous Equations with constant coefficients. Wronskian and general solution. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration.	CSO 2.1: To define and explain First order differential equation (K+U) CSO 2.2: Discuss on order and degree of differential equation (U) CSO 2.3: To define and discuss on integrating factors and solve problems based on it (K+U+A) CSO 2.4: To discuss various ways to solve 1st order differential equations (U) CSO 2.5: Work out problems based on the various ways to solve 1st order differential equation (A) CSO 2.6: To define and discuss homogenous differential equation (K+U) CSO 2.7: Discuss on ways to solve homogenous equations (U+A) CSO 2.8: Define and explain Wronskian equation and its general solution (K+U) CSO 2.9: To solve problems based on Wronskian CSO 2.10: To introduce the idea of partial differential equations and their difference from ordinary differential equations. (K+U) CSO 2.11: To discuss on ways to solve exact and inexact equations. (A)	8	19	Not to be filled-in
UNIT 3 **Vector Integration**	Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications	CSO 3.1: To define ordinary integrals (K) CSO 3.2: To discuss on various types of integral (U) CSO 3.3: To solve problems based on the various types of integral. (A) CSO 3.4: To define Jacobian (K) CSO 3.5: To discuss on various parameters on Jacobian and solve problems based on it (U+A) CSO 3.6: To define and discuss flux of a vector filed (U) CSO 3.7: To define and discuss Gauss Divergence Theorem and Stokes Theorems (K+U) CSO 3.8: To worked out problems based on	8	19	Not to be filled-in

		the theorems (A)			
UNIT 4 Orthogonal Curvilinear Coordinates	Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems	CSO 4.1: To Define and understand orthogonal curvilinear coordinate system (K+U) CSO 4.2: To Derive and discuss the various parameters of Orthogonal Curvilinear Coordinates (U+A) CSO 4.3: To Explain spherical and cylindrical coordinate systems and its relationship. (U) CSO 4.4: To solve problems based on co-conversion from on coordinate system to another (A) CSO 4.5: To Derivation of Gradient, Divergence, Curl and Laplacian based on orthogonal curvilinear coordinate system (A) CSO 4.6: To solve problems based conversion (A)	8	17	Not to be filled-in
UNIT 5 Dirac delta functions and Introduction to probability	Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. Discrete and continuous random variables, Probability distribution functions, Binomial, Poisson and Gaussian distributions, Mean and variance of these Distributions.	CSO 5.1: To define Dirac delta function (K) CSO 5.2: To explain the Dirac delta functions and its properties (K+U) CSO 5.3: To workout problems based on Dirac delta functions (A) CSO 5.4: To discuss its representation as limit of Gaussian function and rectangular function (K+U) CSO 5.5: To discuss examples to complement the above representation(A) CSO 5.6: To Define and explain on probability and its types (K+U) CSO 5.7: To define and explain variables (K) CSO 5.8: To introduce the idea of random and discrete variables (U) CSO 5.9: To explain on the various probability distribution and solve problems based on it. (U+A) CSO 5.10: To define mean and variance in probability(K) CSO 5.11: To supplement the definition with some problem solving(A)	8	20	Not to be filled-in

SUGGESTED READINGS:

1. G.B. Arfken, H.J. Weber, F.E. Harris, *Mathematical Methods for Physicists*, 7th Edition, Elsevier, 2013.
2. E.A. Coddington, *Anintroduction to ordinary differential equations*, PHI learning 2009.
3. George F. Simmons, *Differential Equations*,McGraw Hill, 2007.
4. James Nearing, *Mathematical Tools for Physics*, Dover Publications, 2010.
5. D.A. McQuarrie, *Mathematical methods for Scientists and Engineers*, Viva Book, 2003.
6. D.G. Zill & W.S. Wright ,*Advanced Engineering Mathematics* , 5 Edition, Jones & Bartlett Learning , 2012.
7. S.Pal and S.C. Bhunia, *Engineering Mathematics*,Oxford University Press ,2015.
8. Erwin Kreyszig, *Advanced Engineering Mathematics*, Wiley India, 2008.
9. K.F.Riley&M.P.Hobson ,*Essential Mathematical Methods*,Cambridge Univ. Press 2011.

Semester	I
Paper Code	PHC 1.1(P)
Paper Title	Mathematical Physics –I
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

• Prepare algorithms and flowcharts for solving a problem.
• Design, code and test programs in C and C++ in the process of solving various
• Solve physics problems involving differentiation

Topics	**Description with application**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Review of C & C++ Programming Fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Maximum minimum and range of numbers, addition, multiplication and inverse of matrix, solution of quadratic equation, solution of simultaneous equation, values of sine, cosine and exponential function using their series expansion
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)
Interpolation by Newton Gregory Forward and Backward difference	Evaluation of trigonometric functions e.g sin θ, cos θ, tan θ, etc.

formula, Error estimation of linear interpolation	
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa.

SUGGESTED READINS:

1.S.S. Sastry, *Introduction to Numerical Analysis*, 5th Edn. PHI Learning Pvt. Ltd, 2012.
2. J. Hubbard ,*Schaum's Outline of Programming with C++*,McGraw-Hill Pub, 2000.
3. W.H. Pressetal, *Numerical Recipes in C: The Art of Scientific Computing*, 3rd Edn., 2007.
4.U.M. Ascher& C. Greif, *A first course in Numerical Methods*,PHI Learning,2012.
5.K.E. Atkinson, *Elementary Numerical Analysis*, 3rd Edn.,Wiley India Edition ,2007.
6. R.W. Hamming, *Numerical Methods for Scientists & Engineers*,Courier Dover Pub.,1973.
7.T.Pang,*An Introduction to computational Physics*, 2nd Edn. , Cambridge Univ. Press ,2006.
8. Darren Walker, *Computational Physics*, 1st Edn., Scientific International Pvt. Ltd.,2015.

Semester	I
Paper Code	PHC 1.2
Paper Title	Mechanics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Mechanics**:

CO 1:	To make the students understand the fundamentals of dynamics.
CO 2:	To learn the concept of dynamics and rotational dynamics.
CO 3:	To understand gravitation and central force motion.
CO 4:	To make the students learn non-inertial systems and Special theory of relativity.
CO 5:	To make the students well aware of the concept of oscillations , elasticity and fluid motion.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Fundamentals of Dynamics	Reference frames. Inertial frames. Galilean transformations;	**CSO 1.1:** To define Dynamics. (K) **CSO 1.2:** To define reference frame and inertial frame. (K) **CSO 1.3:** To derive the Galilean transformation equations. (A)	10	24	Not to be filled-in

	Galilean invariance. Momentum of variable mass system: motion of rocket. Motion of a projectile in a uniform gravitational field. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. **Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy .Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.	**CSO 1.4:** To learn Galilean invariance.(K) **CSO 1.5:** To define variable mass system.(K) **CSO 1.6:** To apply the laws of motion to study projectile motion and rocket motion.(A) **CSO 1.7:** To learn the dynamics of a sytem of particles.(U) **CSO 1.8:** To define centre of mass and derive the formula for it.(K&A) **CSO 1.9:** To define momentum and explain the principle of conservation of momentum. (U) **CSO 1.10:** To define impulse and derive the formula for it.(K&A) **CSO 1.11:** To define work and energy and derive the work energy theorem. (K&A) **CSO 1.12:**To differentiate between conservative and non-conservative forces. (U) **CSO 1.13:**To explain potential energy and draw the energy diagram.(U) **CSO 1.14:**To define stable and unstable equilibrium.(K) **CSO 1.15:**To Define elstic potential energy. (K) **CSO 1.16:** To derive the formula for force as gradient of potential energy.(A) **CSO 1.17:** To derive the work done by non-conservative forces.(A) **CSO 1.18:**To Explain the law of conservation of energy.(U)			
UNIT 2 Collisions, Rotational Dynamics	Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. Angular momentum of a particle and a system of particles. Torque. Principle of conservation of angular momentum. Kinetic energy of rotation. Rotation about a fixed axis.	**CSO 2.1:** To define collision.(K) **CSO 2.2:** To define elastic and inelastic collisions.(K) **CSO 2.3:** To obtain the relations for elastic and inelastic collisions.(U) **CSO 2.4:** To obtain the expressions for centre of mass and laboratory frames. (U) **CSO 2.5:** To define rotational dynamics.(K) **CSO 2.6:** To define angular momentum.(K) **CSO 2.7:** To explain angular momentum of a particle and system of particles.(U) **CSO 2.8:** To define torque and obtain the expression for it.(K&U)	8	19	Not to be filled-in

	Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.	**CSO 2.9:** To explain the principle of conservation of angular momentum. (U) **CSO 2.10:** To define kinetic energy and obtain the expression for kinetic energy of rotation.(K&A) **CSO 2.11:**To derive the expression for rotation about a fixed axis. **CSO 2.12:**To define moment of inertia and derive its formula. (K) **CSO 2.13:** To find the moment of inertia for rectangular, cylindrical and spherical bodies. (A)			
UNIT 3 Gravitation and Central Force Motion	Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to a spherical shell and solid sphere. **Motion of a Particle under a Central Force Field:** Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).	**CSO 3.1:** To define gravitation and central force.(K) **CSO 3.2:** To explain the law of gravitation.(U) **CSO 3.3:** To define gravitational potential energy, inertial mass and gravitational mass.(K) **CSO 3.4:** To obtain expression for gravitational potential due to spherical shell and solid sphere.(U) **CSO 3.5:** To obtain expression for gravitational field due to spherical shell and solid sphere.(U) **CSO 3.6:** To explain two-body problem and derive its reduction to one-body problem and find the solution.(U) **CSO 3.7:** To derive the energy equation and explain the energy diagram. **CSO 3.8:** To state the Kepler's laws.(K) **CSO 3.9:** To explain motion of a satellite in circular orbit and write its applications.(U) **CSO 3.10:** To explain Geosynchronous orbits.(U) **CSO 3.11:** To explain Weightlessness.(U) **CSO 3.12:** To explain the basic idea of global positioning system(GPS).(U)	9	19	Not to be filled-in
UNIT 4 Non-Inertial Systems, Special Theory of Relativity	Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems.	**CSO 4.1:** To define non-inertial frames and fictitious forces. (K) **CSO 4.2:** To explain Uniformly rotating frame.(U) **CSO 4.3:** To explain the Laws of Physics in rotating coordinate systems.(U) **CSO 4.4:**To define Centrifugal force.(K)			Not to be filled-in

	Centrifugal force. Coriolis force and its applications. Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence.	**CSO 4.5:** To define coriolis force and write its applications.(K&U) **CSO 4.6:** To explain the Michelson-Morley Experiment and find its outcome.(U) **CSO 4.7:**To write the postulates of Special Theory of Relativity.(K) **CSO 4.8:**To derive Lorentz Transformation equations.(A) **CSO 4.9:** To explain time dilation.(U) **CSO 4.10:** To derive the expression for relativistic addition of velocities.(A) **CSO 4.11:**To derive the expression for Variation of mass with velocity.(A) **CSO 4.12:**To define massless Particles (photon) and derive an expression for it.(K&A) **CSO 4.13:**To obtain the expression for Mass-energy Equivalence.(U)			
UNIT 5 Oscillations, Elasticity, Fluid Motion	SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations. Resonance, sharpness of resonance and Quality Factor. Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.	**CSO 5.1:** To define simple harmonic oscillations. (K) **CSO 5.2:** To derive the differential equation of SHM and find its solution .(A) **CSO 5.3:**To define Kinetic energy, potential energy, total energy and find their time-average values.(K&A)) **CSO 5.4:** To define damped oscillation and obtain the expression for it. (K&U) **CSO 5.5:** To define forced oscillation and obtain the expression for it. (K&U) **CSO 5.6:** To define resonance, sharpness of resonance and Quality Factor and obtain expressions for each. (K&A) **CSO 5.7:** To define elasticity.(K) **CSO 5.8:** To define the types of elastic constants.(K) **CSO 5.9:** To derive the relation between Elastic constants.(A) **CSO 5.10:** To derive the expression for twisting torque on a Cylinder or Wire.(A) **CSO 5.11:** To define streamline flow and turbulent flow. (K) **CSO 5.12:** To derive expression for volume of a liquid flowing through a Capillary Tube (Poiseuille's Equation). (U)	9	19	Not to be filled-in

SUGGESTED READINGS:

1. D.Kleppner,R.J.Kolenkow,*An Introduction to Mechanics*, McGraw-Hill ,1973.
2. C.Kittel,W.Knight ,*Mechanics*,BerkeleyPhysics,Vol.1, ,et.al. TataMcGraw-Hill ,2007.
3. G.R.Fowles and G.L.Cassiday,*Analytical Mechanics*, CengageLearning,2005.
4. R.P.Feynman,R.B.Leighton,M.Sands,*Feynman Lectures,Vol.I*, Pearson Education 2008.
5. R.Resnick,*Introduction to Special Relativity*, John Wiley and Sons 2005.
6. Ronald Lane Reese,*University Physics*, ThomsonBrooks/Cole 2003.
7. D.S.Mathur,*Mechanics,*S.ChandandCompanyLimited,2000.
8. F.WSears,M.WZemansky,H.DYoung13,*University Physics*, AddisonWesley ,1986.

Semester	I
Paper Code	PHC 1.2(P)
Paper Title	Mechanics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Students would perform basic experiments related to mechanics and also get familiar with various measuring instruments, would learn the importance of accuracy of measurements.

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

SUGGESTED READINGS:

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

Semester-II

Semester	II
Paper Code	PHC 2.1
Paper Title	Electricity and Magnetism
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Electricity and Magnetism**:

CO 1:	To make the students aware of the electric field and basic concepts of electric potential.
CO 2:	To aid the students in the understanding of Electrostatic energy and dielectric properties of matter**.**
CO 3:	To create an understanding among the students, the Magnetic field and its applications and Ballistic Galvanometer.
CO 4:	To inculcate and create interest among students in the understanding of Magnetic properties of matter and Electromagnetic Induction
CO 5:	To assist the students in the understanding of Electric circuits and the Network theorems..

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Electric Field and Electric Potential	Electric field: Electric field lines. Electric flux. Gauss 'Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace 's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole.	**CSO 1.1:** To define the term electric field. (K) **CSO 1.2:** To define electric field lines. (K) **CSO 1.3:** To define electric flux. (K) **CSO 1.4:** To Demonstrate Gauss law for the electric field, and apply to charge distributions with spherical, cylindrical and planar symmetry. (A) **CSO 1.5:** To discuss the conservative nature of electrostatic field. (U) **CSO 1.6:** To define electrostatic potential. (A) **CSO 1.7:** To define Laplace's and Poisson equations. (K) **CSO 1.8:** To define and determine the uniqueness theorem. (A) **CSO 1.9:** To discuss the potential and electric field of dipole. **CSO 1.10:** To derive the Laplace and Poisson equations.	7	18	Not to be filled-in

UNIT 2 Electrostatic energy and dielectric properties of matter.	Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric **Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant.. Displacement vector **D**. Relations between **E**, **P** and **D**.	**CSO 2.1:** To define electrostatic energy. (K) **CSO 2.2:** To define and characterise conductors in an electrostatic field. (A) **CSO 2.3:** To explain the surface charge and force on a conductor. (U) **CSO 2.4:** To discuss the capacitance of a charged conductors. (U) **CSO 2.5:** To explain capacitor filled with dielectric. (U) **CSO 2.6:** To describe dielectric properties of matter. (U) **CSO 2.7:** To explain electric field in matter. (U) **CSO 2.8:** To define polarization and polarization charges. (K) **CSO 2.9:** To define and explain electrical susceptibility and dielectric constant. (K) **CSO 2.10:** To examine displacement vector **D** (A) **CSO 2.11:** To compare and contrast the relations between **E, P and D.** (U) **CSO 2.12:** To derive electrostatic energy for system of charges. (A)	9	20	Not to be filled-in
UNIT 3 Magnetic field and Ballistic Galvanometer	Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart 's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment. Torque on a current loop in a uniform Magnetic Field. Ampere 's Circuital Law and its application to	**CSO 3.1:** To define magnetic force. (K) **CSO 3.2:** To explain magnetic force between current element. (U) **CSO 3.3:** To define Magnetic Field. (K) **CSO 3.4:** To describe Biot- Savart's Law and examine its application on straight wire and circular loop. (A) and (K) **CSO 3.5:** To describe current loop as a magnetic dipole and explain its dipole moment. (K) **CSO 3.6:** To demonstrate torque on a current loop in a uniform magnetic field. (A) **CSO 3.7:** To explain Ampere's Circuital Law. (U) **CSO 3.8:** To state and explain the properties of magnetic field. (K) **CSO 3.9:** To define vector potential. (K) **CSO 3.10:** To analyse the magnetic force on point charge, current carrying wire and between current elements. (A)	12	23	Not to be filled-in

	(1) Solenoid and (2) Toroid. Properties of **B**. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. **Ballistic Galvanometer:** Ballistic Galvanometer Current and Charge Sensitivity.	**CSO 3.11:** To describe Ballistic Galvanometer. (K) **CSO 3.12:** To apply ampere,s law for solenoid and toroid. (A) **CS) 3.13:** To discuss current and charge sensitivity of Ballistic Galvanometer. (U)			
UNIT 4 **Magnetic properties of matter and Electromagnetic Induction**	Magnetization vector **(M).** Magnetic Intensity **(H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis. **Electromagnetic Induction:** Faraday 's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.	**CSO 4.1:** To define magnetization vector M. (K) **CSO 4.2:** To explain Magnetic Intensity H. (U) **CSO 4.3:** To define magnetic susceptibility and permeability. (K) **CSO 4.4:** To derive the relation between B, H, M. (A) **CSO 4.5:** To define Ferromagnetism. (K) **CSO 4.6:** To examine B-H curve and construct hysteresis loop of a ferromagnetic material. (A) **CSO 4.7:** To define electromagnetic induction. (K) **CSO 4.8:** To explain Faraday's law and its derivation. (A) **CSO 4.9:** To explain Lenz's Law. (U) **CSO 4.10:** To explain Self inductance and mutual inductance. (U) **CSO 4.11:** TO derive Reciprocity theorem. (A) **CSO 4.12:** To evaluate energy stored in a magnetic field. (A) **CSO 4.13:** To explain Maxwell's Equations. (U) **CSO 4.14:** To construct the charge conservation and displacement current of electromagnetic waves. (A)	8	19	Not to be filled-in
UNIT 5 Electric circuits and Network theorems.	AC Circuits: Kirchhoff's laws for AC circuits. Complex	**CSO 5.1:** To define AC Circuits. (K) **CSO 5.2:** To explain Kirchoff's laws for AC circuits. (U)	9	20	Not to be filled-in

	Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.	**CSO 5.3:** To explain complex reactance and Impedance in an electrical circuit. (U) **CSO 5.4:** To describe LCR series Circuit. (K) **CSO 5.5:** To explain Parallel LCR circuit. (U) **CSO 5.6:** To define and explain Ideal Constant voltage and constant current sources. (K) **CSO 5.7:** To construct LCR series circuit and find its resonance factor, power, dissipation, quality factor and the band width. (A) **CSO 5.8:** To explain the Network theorems and examine their application to dc circuits. (U) **CSO 5.9:** To derive thevenin theorem. (A) **CSO 5.10:** To derivenorton theorem. (A) **CSO 5.11:** To derive superposition theorem. (A) **CSO 5.12:** To construct the reciprocity theorem. (A) **CSO 5.13:** To construct the maximum power transfer theorem. (A)			

SUGGESTED READINGS:

1. S. Mahajan and Choudhury, *Electricity, Magnetism & Electromagnetic Theory*, Tata McGraw, 2012.
2. Edward M. Purcell, *Electricity and Magnetism*, McGraw-Hill Education ,1986 .
3. D.J. Griffiths, *Introduction to Electrodynamics*, 3rd Edn., Benjamin Cummings 1998.
4. R.P.Feynman, R.B.Leighton, M. Sands, *Feynman Lectures Vol.2*, Pearson Education 2008.
5.M.N.O. Sadiku, *Elements of Electromagnetics*, Oxford University Press ,2010.
6. J.H.Fewkes&J.Yarwood ,*Electricity and Magnetism*, Vol. I, Oxford Univ. Press 1991.

Semester	II
Paper Code	PHC 2.1(P)
Paper Title	Electricity and Magnetism
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Demonstration and practical laboratory experiments on electrical circuits and devices and uses of different electrical devices is the objective of the course. Moreover, raining on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors is also an aim of the course.

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

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House ,1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers ,reprinted 1985.
3. S. Panigrahi and B. Mallick, *Engineering Practical Physics*, Cengage Learning,2015.
4. D. P. Khandelwal, *A Laboratory Manual of Physics for undergraduate classes*,Vani Pub ,1985.

Semester	II
Paper Code	PHC 2.2
Paper Title	Waves and Optics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Waves and Optics**:

CO 1:	To create understanding about the Superposition of Harmonic Oscillators.
CO 2:	To make the students understand the velocity of waves and superposition of harmonic waves.
CO 3:	To study wave optics and interference in waves.
CO 4:	To study Michelson Interferometer used to observe fringes and study the phenomenon of diffraction
CO 5:	To understand Fresnel diffraction and holography using the concept of waves.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Superposition of Harmonic oscillators	Superposition of two collinear oscillations having (1) equal frequencies and (2)different frequencies(Beats).Superposition of N collinear Harmonic Oscillations with (1)equal phase differences and (2)equal frequency differences. **Superposition of two perpendicular Harmonic Oscillations:** Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses. **Wave Motion:** Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave.	**CSO 1.1:** To define periodic motion and simple harmonic motion.(K) **CSO 1.2:** To define frequency, vibration, amplitude and time period. (K) **CSO 1.3:** To define the Principle of Superposition and apply it to find the superposition of two collinear oscillations having same frequencies and different frequencies.(K&A) **CSO 1.4:** To find the formula for Superposition of N collinear Harmonic Oscillations with (1)equal phase differences and (2)equal frequency differences. (U) **CSO 1.5:** To define Lissajous figures and used it to understand simple harmonic vibrations of same frequency and different frequencies. (K&A) **CSO 1.6:**To define wave motion.(K) **CSO 1.7:** To define transverse and longitudinal waves.(K) **CSO 1.8:** To define spherical and plane waves. (K) **CSO 1.9:** To define particle velocity, wave velocity and group velocity and find the relation between them.(K) **CSO 1.10:** To derive the	13	25	Not to be filled-in

		equation of a plane progressive wave(A) **CSO 1.11:**To derive the differential wave equation. (A)			
UNIT 2 **Velocity of Waves, Superposition of Two Harmonic Waves**	Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **Superposition of Two Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes.	**CSO 2.1:** To derive the Velocity of Transverse Vibrations of Stretched Strings.(A) **CSO 2.2:** To find the solution of a wave equation.(U) **CSO 2.3:** To derive the Velocity of Longitudinal Waves in a Fluid in a Pipe. (A) **CSO 2.4:** To derive Newton's formula for the velocity of sound. (A) **CSO 2.5:** To explain Laplace correction.(U) **CSO 2.6:** To define stationary waves.(K) **CSO 2.7:** To explain the standing waves with two fixed ends of a string. (U) **CSO 2.8:** To explain the standing waves with two free ends and one free end.(U) **CSO 2.9:** To derive formula for energy of vibrating string. (A) **CSO 2.10:**To derive a formula for energy in the nth mode of a vibrating string. **CSO 2.11**:To explain wave groups and group velocity.(U) **CSO 2.12**: To study dispersive and no-dispersive media.(U) **CSO 2.13**: To derive the equation for motion of a plucked string and struck string.(A) **CSO 2.14:** To explain Melde's experiment.(U) **CSO 2.15**:To explain longitudinal standing waves and normal modes. (U)	8	19	Not to be filled-in
UNIT 3 **Wave Optics, Interference**	Electromagnetic nature of light. Definition and properties of wavefront. Huygens Principle. Temporal and Spatial Coherence. **Interference:** Division of	**CSO 3.1:** To define light.(K) **CSO 3.2:** To explain the electromagnetic nature of light.(U) **CSO 3.3:** To define wavefront and explain its types.(K) **CSO 3.4:** To explain the	8	20	Not to be filled-in

	amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films, Newton's Rings: Measurement of wavelength and refractive index.	Huygen's Principle using the concept of wavefront. (U) **CSO 3.5:** To state the difference between spatial and temporal coherence. (K) **CSO 3.6:** To define the principle of interference. (K) **CSO 3.7:** To find the condition necessary to observe the interference of two light beams. (U) **CSO 3.8:** To define constructive and destructive interference. (K) **CSO 3.9:** To define coherent sources.(K) **CSO 3.10:** To explain the methods for obtaining the interference pattern.(U) **CSO 3.11:**To explain Young's double slit experiment,Lloyd's mirror and Fresnel's biprism. . (U) **CSO 3.12:** To understand Stoke's treatment.(U) **CSO 3.13:** To explain the interference in thin films. (U) **CSO 3.14**:To give a brief introduction of Newton's rings and find its Wavelength and refractive index. (U)			
UNIT 4 **Interferometers, Diffraction**	**Interferometers:** Michelson Interferometer- (1)Idea of form of fringes(No theory required),(2)Determination of Wavelength,(3)Wavelength Difference,(4)Refractive Index, and(5)Visibility of Fringes. Fabry – perot interferometer. **Diffraction:** Types of diffraction **Fraunhofer diffraction:** Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Diffraction grating. Resolving power of grating.	**CSO 4.1:** To define Interferometer.(K) **CSO 4.2:** To understand the working of Michelson's interferometer .(U) **CSO 4.3:** To explain Fabry – perot interferometer. (U) **CSO 4.4:** To define diffraction.(K) **CSO 4.5:** To give the difference between diffraction and interference.(K) **CSO 4.6:** To explain the types of diffraction. (U **CSO 4.7:** To explain the different types of Fraun hoffer's class of diffraction(single slit, circular aperture,double slit). (A) **CSO 4.8:** To define resolving power and limit of resolution.(K) **CSO 4.9:** To give the	8	18	Not to be filled-in

		Rayleigh's criterion for resolution.(K) **CSO 4.10:** To explain the resolving power of telescope. (U) **CSO 4.11:** To define diffraction grating and find resolving power of a diffraction grating. (K)			
UNIT 5 **Fresnel Diffraction, Holography**	**Fresnel Diffraction:** Fresnel's Assumptions .Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge. **Holography:** Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.	**CSO 5.1:** To explain Fresnel's assumptions. (U) **CSO 5.2:** To explain Fresnel's Half-Period Zones for Plane Wave.(U) **CSO 5.3:** To find the radii and area of half-period zones. (U) **CSO 5.4:** To explain rectilinear propagation of light.(U) **CSO 5.5:**To define zone plate and explain its construction.(K) **CSO 5.6:** To define positive and negative zone plates.(K) **CSO 5.7:**To explain the theory and multiple foci of a zone plate. (U) **CSO 5.8:** To explain cornu's spiral.(U) **CSO 5.9:**To explain Fresnel's integrals.(U) **CSO 5.10:** To explain Fresnel diffraction at a straight edge. (U) **CSO 5.11:** To define holography.(K) **CSO 5.12:** To give the principle of holography.(K) **CSO 5.13:** To explain the recording of a hologram.(U) **CSO 5.14:** To explain the reconstruction of the image from a hologram. (U) **CSO 5.15:** To derive the equation for interference between two plane waves.(A) **CSO 5.16:**To explain the point source of holograms. (U)	8	18	Not to be filled-in

SUGGESTED READINGS:

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

Semester	II
Paper Code	PHC 2.2(P)
Paper Title	Waves and Optics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The practical knowledge of wave motion doing experiments: Tuning fork, electric vibrations. They would also learn optical phenomena such as interference, diffraction and dispersion and do experiments related to optical devices: Prism, grating, spectrometers

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Kundt's tube experiment.
5. Familiarization with: Schuster`s focusing; determination of angle of prism.
6. To determine refractive index of the Material of a prism using sodium source.
7. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
8. To determine the wavelength of sodium source using Michelson's interferometer.
9. To determine wavelength of sodium light using Fresnel Bi-prism.
10. To determine wavelength of sodium light using Newton 's Rings.
11. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
12. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
13. To determine dispersive power and resolving power of a plane diffraction grating.

SUGGESTED READINGS:

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

Semester-III

Semester	III
Paper Code	PHC 3.1
Paper Title	Mathematical Physics –II
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Mathematical Physics II**:

CO 1:	To make the students understand the Fourier series expansion of periodic and non periodic functions.
CO 2:	To aid the students in the understanding of second order differential equation and help them to solve differential equations by using frobenius methods.
CO 3:	To make the student understand the properties of Bessel and Legengre polynomials.
CO 4:	To make the student understand about the importance of Beta and gamma functions and give ideas about different kind of errors.
CO 5:	To assist the students in the understanding of partial differential of wave and Laplace equations.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Fourier Series	Periodic functions. Dirichlet's Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions.	**CSO 1.1:** To define periodic functions. (K) **CSO 1.2:** To Write Dirichlet's conditions. (K) **CSO 1.3:** To construct periodic functions in a series of sine function. (A) **CSO 1.4:** To construct periodic functions in a series of sine function. (A) **CSO 1.5:** To understand fourier coefficients. (U) **CSO 1.6:** To understand the fourier series in complex form. (U) **CSO 1.7:** To describe even and odd functions and their fourier expansion. (K) **CSO 1.8:** To understand non periodic functions. (U)	9	20	Not to be filled-in

	Application. Parseval Identity.				
UNIT 2 **Frobenius Method and Special Polynomials**	Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations.	**CSO 2.1:** To describe second order differential equations. (K) **CSO 2.2:** To understand singular point of a second order linear differential equations. (U) **CSO 2.3:** To write frobenius method. (K) **CSO 2.4:** To derive Legendre differential equation. (A) **CSO 2.5:** To derive Bessel differential equation. (A) **CSO 2.6:** To derive Hermite differential equation. (A) **CSO 2.7:** To derive Laguerre differential equation. (A) **CSO 2.8:** To understand the generating function of Hermite Polynomial. (U) **CSO 2.9:** To understand the generating function of Laguerre Polynomial. (U)	9	20	Not to be filled-in
UNIT 3 **Properties of Legendre and Bessel Polynomials**	Legendre function: Generating Function, Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)).	**CSO 3.1:** To state generating function. (K) **CSO 3.2:** To write the generating function of Legendre Polynomial. (K) **CSO 3.3:** To write the generating function of Bessel Polynomial. (K) **CSO 3.4:** To understand recurrence relations of Legendre and Bessel Polynomials. (U) **CSO 3.5:** To derive the expansion of the function in series of Legendre Polynomials. (A) **CSO 3.6:** To express the Bessel function of the first kind. (A) **CSO 3.7:** To explain the zeros of Bessel Functions. (U)	9	20	Not to be filled-in
UNIT 4 **Some Special Functions and Theory of Errors**	Beta and Gamma Functions and Relation between them. Relation between Beta and Gamma Functions. **Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Standard and	**CSO 4.1:** To define Beta function. (K) **CSO 4.2:** To define Gamma function. (K) **CSO 4.3:** To explain the relationship between Beta and Gamma functions. (U) **CSO 4.4:** To describe systematic and random errors. (K) **CSO 4.5:** To understand different types of Propagation errors. (U)	7	16	Not to be filled-in

	Probable Error. Least-squares fit. Error in slope and intercept.	**CSO 4.6:** To understand Standard error. (U) **CSO 4.7:** To understand Probable error. (U) **CSO 4.8:** To construct the least square fit error in slope and intercept. (A)			
UNIT 5 Partial Differential Equations	Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes.	**CSO 5.1:** To define partial differential equation. (K) **CSO 5.2:** To understand the solution of partial differential equation by method of separation of variables. (U) **CSO 5.3:** To express the Laplace Equation in rectangular coordinate system. (A) **CSO 5.4:** To discuss Laplace equation. (U) **CSO 5.5:** To express the Laplace equation in cylindrical coordinate system. (A) **CSO 5.6:** To express the Laplace equation in spherical coordinate system. (A) **CSO 5.7:** To discuss the Wave equation. (U) **CSO 5.8:** To derive the wave equation for stretched string. (A) **CSO 5.9:** To derive the wave equation for rectangular membrane. (A) **CSO 5.10:** To derive the wave equation for circular membrane. (A)	11	24	Not to be filled-in

SUGGESTED READINGS:

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

Semester	III
Paper Code	PHC 3.1 (P)
Paper Title	Mathematical Physics- II
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The aim of this course is to

1. Highlights the use of computational methods to solve physical problems.
2. Course will consist of hands-on training on the Problem solving on Computers.

Topics	**Descriptions with applications**
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting,Leas t square fit, Goodness Off it,standard deviation	Ohms law to calculate R,Hooke's law to calculate spring Constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors,eigen values problems	Solution of mesh equations of electric circuits(3meshes) Solution of coupled spring mass systems (3 masses)

Solution of ODE
 	
First order Differential equation Euler, modified Euler and Runge-Kutta second order methods
 	
Second order differential equation Fixed difference method Using Scicos/ xcos
	First order differential equation
	• Radioactive decay
	• Current in RC,LCcircuits with DC source
	• Newton's law of cooling
	• Classical equations of motion Second order Differential Equation
	• Harmonic oscillator(no friction)
	• Damped Harmonic oscillator
	  • Over damped
	  • Critical damped
	  • Oscillatory
	• Forced Harmonic oscillator
	  • Transient and
	  • Steady state solution
	• Apply above to LCR circuits also

	• Generating square wave, sine wave,sawtooth wave • Solution to harmonic oscillator • Study of beat phenomenon • Phases pace plots

SUGGESTED READINGS:

1.K.FRiley,M.P.Hobson and S. J.Bence,*Mathematical Methods for Physics and Engineers*, 3rded.,CambridgeUniversity Press ,2006.
2.A.S.Fokas&M.J.Ablowitz,*ComplexVariables*,8thEd.,CambridgeUniv.Press ,2011.
3.D.G.ZillandP.D.Shanahan ,*First course in complex analysis with applications*, Jones & Bartlett, 1940.
4.H.Ramchandran,A.S.Nair.Scilab(*A free software to matlab*):Chand&Company,2011.
5.Lambert M.Surhone,*Scilab Image Processing*:. Betascript Publishing, 2010.

Semester	III
Paper Code	PHC 3.2
Paper Title	Analog Systems and Applications
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Analog Systems and Applications**:

CO 1:	To create an awareness among the students about Semiconductor Diodes, its mechanism and application
CO 2:	To instil the idea of Two-terminal Devices and Bipolar Junction transistors and its working mechanism among the students
CO 3:	To let the students understand the concepts of Amplifiers and coupled amplifiers and its applications
CO 4:	To inculcate and create interest among students in Feedback Amplifier, Sinusoidal Oscillators and Operational Amplifiers
CO 5:	To assist the students in understanding Applications of Op-Amps

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Semiconductor Diodes	P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation	**CSO 1.1:**To define semiconductor diode (K) **CSO 1.2:**To explain the different types of semiconductors (U) **CSO 1.3:**To explain the semiconductors based on energy level diagram (U) **CSO 1.4:**To define and explain the idea of conductivity, mobility and drift velocity (K+U) **CSO 1.5:**To give the idea on PN junction fabrication (A) **CSO 1.6:**To explain on barrier	7	16	Not to be fille d-in

	for Barrier Potential, Barrier Width and Current for Step Junction.	formation (U) **CSO 1.7:**To explain on the resistance in semiconductor diode (U) **CSO 1.8:**To define and explain the Current Flow Mechanism in Forward and Reverse Biased Diode (U+A) **CSO 1.9:**To show how to derive barrier potential and barrier width equation (U+A) **CSO 1.10:**To work out problems based on the barrier potential and width			
UNIT 2 **Two-terminal Devices and their Applications Bipolar Junction transistors**	Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell **Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.	**CSO 2.1:**To define rectifier (K) **CSO 2.2:**To explain and derive full wave and half wave rectifier equation and calculate its parameters (U+A) **CSO 2.3:**To work out problems based on the rectifier equation (A) **CSO 2.4:**To define and explain on the use of filters in rectifiers (U+A) **CSO 2.5:**To define Zener diode (K) **CSO 2.6:**To discuss Zener diode application as a voltage regulator (U+A) **CSO 2.7:**To discuss the structure and principle of LED, Photodiode and Solar cell (U+A) **CSO 2.8:**To define transistor(K) **CSO 2.9:**To explain on the types of transistors and its characteristics in various modes (U+A) **CSO 2.10:**To define and explain on power amplification factors (K) **CSO 2.11:**To explain the relationship of α and β (A) CSO 2.12: To discuss on the mechanism of current flow (A+U)	11	24	Not to be fille d-in
UNIT 3 **Amplifiers Coupled Amplifier**	Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and	**CSO 3.1:** To define amplifiers (K) **CSO 3.2:**To explain the various ways to bias transistors (U) **CSO 3.3:**To work out problems based on bias of transistors(A) **CSO 3.4:**To define H-parameters and its introduction to transistor equation (K+U) **CSO 3.5:**To analyse single stage CE amplifier using H-parameters(U) **CSO 3.6:**To calculate input, output,	11	24	Not to be fille d-in

	Power Gains. Classification of Class A, B & C Amplifiers. **Coupled Amplifier:** Two stage RC-coupled amplifier and its frequency response	impedance, current, voltage and power gain of CE amplifier (U+A) **CSO 3.7:**To discuss on the classification of amplifiers (U) **CSO 3.8:**To define coupled amplifier and its difference to amplifier (K+U) **CSO 3.9:**To explain on two staged RC coupled amplifier and its frequency response (U) **CSO 3.10:**To study the application of Coupled amplifier(U+A)			
UNIT 4 **Feedback in Amplifier Sinusoidal Oscillators Operational Amplifiers**	Effects of Positive and Negative, Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **Operational Amplifiers (Black Box approach)**: Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.	**CSO 4.1:**To define Feedback in amplifiers (K) **CSO 4.2:**To discuss on the types of feedback and its effects on various parameters like input, impedance, output, etc (U) **CSO 4.3:**To define noise and distortion(K) **CSO 4.4:**To Discuss on the application feedback in oscillators.(U+A) **CSO 4.5:** To define and explain RC phase shift oscillator, Hartley and Colpitts oscillator (A+U) **CSO 4.6:**To explain Barkhausen's Criterion for Self-sustained oscillator **CSO 4.7:**To define operational amplifier and its difference from normal amplifier (U) **CSO 4.8:**To explain the characteristics of op-amp ic 741 (U) **CSO 4.9:**To explain closed and open loop gain (U) **CSO 4.10:**To give an idea on slew rate and virtual ground (U)	8	18	Not to be fille d-in
UNIT 5 Applications of Op-Amps	(1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator	**CSO 5.1:**To explain on inverting and non-inverting amplifiers(U+A) **CSO 5.2:**To discuss on the use of op-amps as an adder, subtractor, differentiator, and integrator. (U+A) **CSO 5.3:**To discuss on wein bridge oscillator (A) **CSO 5.4:**To explain Op-amps as a log amplifier(A)	8	18	Not to be fille d-in

SUGGESTED READINGS:

1. J. Millman and C.C. Halkias, *Integrated Electronics*,Tata Mc-Graw Hill ,1991.
2. J.D. Ryder, Electronics*: Fundamentals and Applications*,Prentice Hall ,2004.
3. B.G.Streetman&S.K.Banerjee, *Solid State Electronic Devices*, 6th Edn.,2009.
4. S.Salivahanan&N.S.Kumar, PHI *Learning Electronic Devices & circuits*, 3rd Ed., Tata Mc-Graw Hill ,201.,
5. R. A. Gayakwad, *OP-Amps and Linear Integrated Circuit*, 4th edition, Prentice Hall, 2000.

Semester	III
Paper Code	PHC 3.2(P)
Paper Title	Analog Systems and Applications
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The objective of this is to learn fundamentals of electronic devices, design and apply them to electronic circuits.

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage, gain of a single stage RC-coupled transistor amplifier.
7. To design a phase shift oscillator of given specifications using BJT.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design an inverting amplifier using Op-amp (741,351) for dc input voltage and study its closed loop gain.
10. To design inverting amplifier using Op-amp (741,351) and study its frequency response
11. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
12. To investigate the use of an op-amp (741,351) as an Integrator and Differentiator.
13. To add two dc voltages using Op-amp (741,351) in inverting and non-inverting mode
14. To investigate the use of an op-amp (741,351) as adder and subtractor.

SUGGESTED READINGS:

1. P.B. Zbar, A.P. Malvino, M.A. Miller, *BasicElectronics: A text lab manual*, Mc-Graw Hill ,1994.
2. Albert Malvino,*Electronic Principle*, Tata Mc-Graw Hill, 2008.

Semester	III
Paper Code	PHC 3.3
Paper Title	Thermal Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **THERMAL PHYSICS**:

CO 1:	To introduce students to thermodynamics andacquire knowledge of the zeroth, first and second law of thermodynamics
CO 2:	To aid the students in the understanding of Entropy and Thermodynamic Potential.
CO 3:	To create an understanding among the students about the Maxwell thermodynamic relation, its application and the different phase transition involved in thermal physics.
CO 4:	To inculcate and create interest among students in the understanding of Kinetic theory of gases based on Maxwell- Boltzmann law of distribution of velocities and molecular collisions.
CO 5:	To assist the students in the understanding of Real gases.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Thermodynamics: zeroth, first and second law of thermodynamics	Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **Second Law of Thermodynamics**: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work.	**CSO 1.1:** To describe extensive and intensive thermodynamic variables. (K) **CSO 1.2:** To define thermodynamic equilibrium. (K) **CSO 1.3:** To state and describe zeroth law of thermodynamics. (K) **CSO 1.4:** To discuss the concept of temperature. (U) **CSO 1.5:** To elaborate the concept of work and heat. (U) **CSO 1.6:** To describe state functions. (K) **CSO 1.7:** To state the first law of thermodynamics and describe its differential form(K) **CSO 1.8:** To evaluate general relation between CP and CV. (A) **CSO 1.9:** To derive work done during isothermal process. (A) **CSO 1.10:** To derive work done during adiabatic process. (A) **CSO 1.11:** To discuss compressibility and expansion coefficient. (U) **CSO 1.12:** To state second law of thermodynamics. (K) **CSO 1.13:** To discuss reversible and irreversible process with examples. (U)	15	30	Not to be filled-in

	Heat Engines. Carnot 's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot 's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.	**CSO 1.14:** To compare conversion of work into heat and heat into work. (U) **CSO 1.15:** To discuss heat engines. (U) **CSO 1.16:** To elaborate Carnot engine and its efficiency. (U) **CSO 1.17:** To discuss refrigerator and coefficient of performance. (U) **CSO 1.18:** To discuss Kelvin-Planck and Clausius statements and their equivalence. (U) **CSO 1.19:** To elaborate Carnot's theorem. (U) **CSO 1.20:** To apply the second law of thermodynamics and study thermodynamic scale of temperature and its equivalence to perfect gas scale. (A)			
UNIT 2 **Entropy and Thermodynamic Potentials**	Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **Thermodynamic Potentials**: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications.	**CSO 2.1:** To explain the concept of Entropy. (U) **CSO 2.2:** To discuss Clausius theorem. (U) **CSO 2.3:** To discuss Clausius inequality. (U) **CSO 2.4:** To describe second law of thermodynamics in terms of Entropy. (K) **CSO 2.5:** To explain entropy changes in reversible and irreversible processes with examples. (U) **CSO 2.6:** To describe the principle of increase of entropy. (K) **CSO 2.7:** To illustrate temperature- entropy diagrams for Carnot's cycle. (A) **CSO 2.8:** To state and describe the third law of thermodynamics. (K) **CSO 2.9:** To explain the unattainability of absolute zero. (U) **CSO 2.10:** To classify thermodynamic potentials- Internal Energy definition and properties. (U)	8	18	Not to be filled-in

		CSO 2.11: To classify thermodynamic potentials- Enthalpy. (U) **CSO 2.12:** To classify thermodynamic potentials- Helmholtz free energy. (U) **CSO 2.13:** To classify thermodynamic potentials- Gibb's free energy. (U) **CSO 2.14:** To apply thermodynamic potential and study its application. (A)			
UNIT 3 **Maxwell's Thermodynamic Relations and Phase transitions.**	Derivations and applications of Maxwell 's Relations, Maxwell 's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases **Phase Transition:** First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations	**CSO 3.1:** To derive Maxwell's thermodynamic relations. (A) **CSO 3.2:** To derive Clausius Clapeyron equation using Maxwell's relation. (A) **CSO 3.3:** To express the value of Cp-Cv using Maxwell's relation. (A) **CSO 3.4:** To derive first and second Tds equation using maxwell's relation. (A) **CSO 3.5:** To determine Joule – kelvin coefficient for Ideal and Van del Waal gases using Maxwell's relation. (A) **CSO 3.6:** To discuss first and second order phase transitions with examples. (U) **CSO 3.7:** To determine Clausius Clapeyron equation. (A) **CSO 3.8:** To explain Ehrenfest equations. (U)	8	18	Not to be filled-in
UNIT 4 **Kinetic Theory of Gases: Distribution of Velocities and Molecular Collisions**	**Distribution of Velocities**: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required)	**CSO 4.1:** To derive Maxwell's Boltzmann law of distribution of velocities in an ideal gas. (A) **CSO 4.2:** To explain experimental verification of MB law of distribution of velocities- Doppler broadening of spectral lines. (U) **CSO 4.3:** To explain experimental verification of MB law of distribution of velocities- Stern's experiment. (U) **CSO 4.4:** To determine mean velocity. (A) **CSO 4.5:** To determine RMS velocity. (A) **CSO 4.6:** To determine most probable velocity. (A)	7	17	Not to be filled-in

	Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.	**CSO 4.7:** To describe degrees of freedom. (K) **CSO 4.8:** To define law of equipartition of energy. (K) **CSO 4.9:** To describe mean free path. (K) **CSO 4.10:** To explain collision probability. (U) **CSO 4.11:** To explain the estimates of mean free path. (U) **CSO 4.12:** To explain transport phenomenon in ideal gases-viscosity. (U) **CSO 4.13:** To explain transport phenomenon in ideal gases-thermal conductivity. (U) **CSO 4.14:** To explain transport phenomenon in ideal gases-diffusion. **CSO 4.15:** To discuss Brownian motion and its significance. (U)			
UNIT 5 **Real Gases**	Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Boyle Temperature. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Joule-Thomson Cooling.	**CSO 5.1:** To describe behaviour of real gases due to deviations from the Ideal Gas. (K) **CSO 5.2:** To explain the Virial equation. (U) **CSO 5.3:** To explain Abdrew's experiment on CO2 gas. (U) **CSO 5.4:** To describe the critical constants. (K) **CSO 5.5:** To derive Van Der Waal's equation of state for real gases. (A) **CSO 5.6:** To derive values of critical constants. (A) **CSO 5.7:** To explain Boyle's temperature. (U) **CSO 5.8:** To discuss the law of corresponding states. (U) **CSO 5.9:** To compare experimental curves. (A) **CSO 5.10:** To explain P-V diagram. (U) **CSO 5.11:** To explain Joule's experiment. (U) **CSO 5.12:** To discuss free adiabatic expansion of a perfect gas. (U)	7	17	Not to be filled-in

		CSO 5.13: To explain Joule-Thomson effect for real and van der waal gases. (U) **CSO 5.14:** To examine Joule-Thomson cooling. (A)			

SUGGESTED READINGS:

1. M.W. Zemansky, Richard Dittman, *Heat and Thermodynamics*, McGraw-Hill, 1981.
2. MeghnadSaha, and B.N.Srivastava, *A Treatise on Heat*, Indian Press, 1958.
3. S. Garg, R. Bansal and Ghosh, *Thermal Physics*, 2nd Edition, Tata McGraw-Hill, 1993.
4. Carl S. Helrich, *Modern Thermodynamics with Statistical Mechanics*, Springer, 2009.
5. Sears & Salinger, *Thermodynamics, Kinetic Theory & Statistical Thermodynamics*, Narosa, 1988.
6. S.J. Blundell and K.M. Blundell, *Concepts in Thermal Physics*, 2nd Ed., Oxford University Press, 2012.
7. A. Kumar and S.P. Taneja, *Thermal Physics*, R. Chand Publications, 2014.

Semester	III
Paper Code	PHC 3.3(P)
Paper Title	Thermal Physics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The objective of this lab coursework is to observe certain laws that have been learnt in theory classes.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the coefficient of linear expansion by optical lever method or any other suitable method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of resistance with temperature by Carry-Foster bridge and hence determine the temperature coefficient of the material using hotplate.
7. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
8. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

SUGGESTED READINGS:

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

Semester-IV

Semester	IV
Paper Code	PHC 4.1
Paper Title	Mathematical Physics – III
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Mathematical Physics III**:

CO 1:	To make the students understand maths of complex number and application of Cauchy-Riemann Equations.
CO 2:	To make the student understand integration of complex variables, Cauchy integral theorem, Cauchy integral formula, Residue Theorem and Taylor and Laurent series for analytic functions.
CO 3:	To be aware of the connection between Fourier and Laplace transforms and be able to use the latter to solve mathematical problems relevant to the physical sciences.
CO 4:	To understand the implications of Laplace transform.
CO 5:	To understand the implications of inverse Laplace transform and Laplace transform to first and second order differential equations

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Complex Analysis	Brief Revision of Complex Numbers and their Graphical Representation. De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Singular functions: poles and branch points, order of singularity, branch cuts.	**CSO 1.1:** To describe complex numbers. (K) **CSO 1.2:** To state De Moivre’s theorem. (K) **CSO 1.3:** To discuss Argand diagram. (U) **CSO 1.4:** To derive De Moivre’s theorem. (A) **CSO 1.5:** To explain the roots of a complex numbers. (U) **CSO 1.6:** To explain the different functions of complex variables. (U) **CSO 1.7:** To examine the analuticity of complex numbers. (A) **CSO 1.8:** To apply Cauchy-Riemann conditions to find the analyticity of complex functions. (A) **CSO 1.9:** To differentiate between a single valued and multi valued functions. (U) **CSO 1.10:** To analyse the pole, branch point and brunch cut of a function. (A)	10	20	Not to be filled-in

UNIT 2 Complex Integration	Integration of a function of a complex variable. Cauchy's Integral theorem, Simply and multiply connected region. Cauchy's Integral formula. Laurent and Taylor's expansion. Residues and Residue Theorem.	**CSO 2.1:** To discuss the integration of a complex variable. (U) **CSO 2.2:** To define simply and multiply connected region. (K) **CSO 2.3:** To state Cauchy integral theorem. (K) **CSO 2.4:** To apply Cauchy integral theorem for simply and multiply connected region. (A) **CSO 2.5:** To state Cauchy integral formula. (K) **CSO 2.6:** To apply Cauchy integral formula to solve different functions. (A) **CSO 2.7:** To derive Laurent and Taylor's theorem. (A) **CSO 2.8:** To define residue. (K) **CSO 2.9:** To explain Cauchy residue theorem. (U) **CSO 2.10:** To calculate the residue of different functions. (A)	9	19	Not to be filled-in
UNIT 3 Integrals Transforms	Fourier Transforms: Fourier Transform. Fourier transform of Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Convolution theorem. Properties of Fourier transform. Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave.	**CSO 3.1:** To state Fourier transform. (K) **CSO 3.2:** To construct the fourier transform of gaussian function, finite wave train function and other functions. (A) **CSO 3.3:** To apply Fourier transform to solve wave equation. (A) **CSO 3.4:** To discuss the derivatives of Fourier transform. (U) **CSO 3.5:** To list the properties of Fourier transform. (K) **CSO 3.6:** To apply Fourier integral to solve Dirac Delta function. (A) **CSO 3.7:** To define convolution theorem. (K) **CSO 3.8:** To express the Fourier transform of convolution. (A) **CSO 3.9:** To derive the three dimentional Fourier transforms. (A) **CSO 3.10:** To discuss Fourier Transform to different applications. (U)	11	25	Not to be filled-in
UNIT 4 Laplace Transforms	Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. Derivatives and Integrals of LTs. LT of Unit Step function,	**CSO 4.1:** To define Laplace Transform. (K) **CSO 4.2:** To write the conditions of Laplace Transform. (K) **CSO 4.3:** To analyse the Laplace Transform of different functions. (A) **CSO 4.4:** To discuss the properties of Laplace Transform. (U) **CSO 4.5:** To apply Laplace Transform	8	18	Not to be filled-in

	Dirac Delta function, Periodic Functions.	to solve unit step function, Dirac Delta function and Periodic function. (A) **CSO 4.6:** To apply Laplace Transform of periodic function to solve some system of period functions. (A) **CSO 4.7:** To construct the derivative of Laplace Transform. (A) **CSO 4.8:** To discuss the integral of Laplace Transform. (U) **CSO 4.9:** To write the formula for Laplace Transform. (K)			
UNIT 5 Convolution Theorem and Laplace Tranforms	Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.	**CSO 5.1:** To define inverse Laplace Transform. (K) **CSO 5.2:** To write the formula for inverse Laplace Transform. (K) **CSO 5.3:** To differentiate between Laplace Transform and inverse Laplace Transform. (U) **CSO 5.4:** To apply Laplace Transform in solving initial value problems. (A) **CSO 5.5:** To discuss convolution theorem. (U) **CSO 5.6:** To understand the Laplace transform to second order differential equation. (U) **CSO 5.7:** To explain the first order coupled differential equation of Laplace Transform. (U) **CSO 5.8:** To apply Laplace Transform to sole damped harmonic oscillator. (A) **CSO 5.9:** To analyse Laplace Transform for simple electrical circuits.(A) **CSO 5.10:** To develop the Laplace Transform for the solution of heat flow on an infinite bar. (A)	8	18	Not to be filled-in

SUGGESTED READINGS:

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

Semester	IV
Paper Code	PHC 4.1(P)
Paper Title	Mathematical Physics-III
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The aim of this course is to

- Highlights the use of computational methods to solve physical problems.
- Course will consist of hands-on training on the Problem solving on Computers.

Scilab/FORTRAN/C/C++ /others based simulations experiments on Mathematical Physics problems like

1. **Solve differential equation**

$$\frac{dy}{dx} = e^{-x} \; with \; y = 0 \; for \; x = 0$$

$$\frac{dy}{dx} + e^{-x} y = x^2$$

2. Dirac Delta Function:

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx$, for $\sigma = 1, 0.1, 0.01$ and show it tends to 5.

3. Fourier Series:

   Program to sum $\sum_{n=1}^{\infty} (0.2)^n$

   Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

   $\int_{-1}^{+1} P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$

   Plot $P_n(x)$, $j_v(x)$

   Show recursion relation

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$

$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

1. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
2. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis:Integrate $1/(x^2+2)$ numerically and check with computer integration.
3. Integral transform: FFT of $e^{!x^2}$

<u>SUGGESTED READINGS:</u>

1. K.FRiley,M.P.Hobson and S.J. Bence, *Mathematical Methods for Physics and Engineers*, 3rd ed., Cambridge University Press, 2006.
2. P.Dennery and A.Krzywicki,*Mathematics for Physicists*,Dover Publications, 1967.
3. A.V and eWouwer,P.Saucez,C.V. Fernandez, *Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications*, Springer ISBN: 978-3319067896, 2014.
4. M.Affouf, *Scilab by example*: ISBN:978-1479203444, 2012.
5. H.Ramchandran,A.S.Nair, *Scilab(A free software to Matlab)*, S.Chand&Company, 2011
6. Lambert M.Surhone, Scilab Image *Processing*, Betascript Publishing, 2010.

Semester	IV
Paper Code	PHC 4.2
Paper Title	Elements of Modern Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Elements of modern physics**:

CO 1:	To make the students understand the principle of quantum mechanics, wave-particle duality and the experimental evidence support theories for photo-electric, Compton scattering. De Broglie wavelength, and should be able to analyse and interpret various phenomena at quantum level.
CO 2:	To understand the foundational principles of quantum mechanics, particularly regarding the limitations on our ability to simultaneously measure certain parts of properties and the consequences of these limitations on understanding of limitation behaviour and atomic structure.
CO 3:	To create an understanding among the students about the Schrodinger equation for non-relativistic particles, two slit interference and Probabilities and normalization with atoms and particles, understand the wave-particle duality and the interpretation of wave functions.
CO 4:	To create comprehensive understanding of quantum mechanical phenomena in confined system, scattering and tunnelling and should be familiar with the nuclear forces, the liquid drop model, and the nuclear shell model, providing insight into the structure and stability of atomic nuclei.
CO 5:	To aid the student in understanding the principle underlying radioactivity, nuclear reactions and laser physics and apply the concept to analyse and interpret various phenomena in nuclear and laser physics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Quantum mechanics through Planck's equation	Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Two slit experiment with electron and proton, Wave description of particles by wave packets. Group and Phase velocities and relation between them. Wave amplitude and wave functions	**CSO 1.1:** To understand plancks quantum hypothesis.(U) **CSO 1.2:** To explain the concept of quantization of energy.(U) **CSO 1.3:** To define and calculate Plancks constant. (K) **CSO 1.4:** To describe light as a collection of photons.(K) **CSO 1.5:** To explain blackbody radiation and its classical problems.(U) **CSO 1.6:** To understand the photoelectric effect and its experiment.(U) **CSO 1.7:** To understand Compton scattering and its implication for the particle like behaviour of photons.(U) **CSO 1.8:** To define and calculate the de Broglie wavelength.(K) **CSO 1.9:** To understand the concept of matter waves.(U) **CSO 1.10:** To explain the Davisson-Germer experiment.(U) **CSO 1.11:**To understand the interference patterns observed in the experiment.(U) **CSO 1.12:** To understand the concept of the wave packets.(U) **CSO 1.13:** To describe how the particles can be described as wave packets.(K) **CSO 1.14:** To define phase velocity and group velocity.(K) **CSO 1.15:** To understand the relation between phase velocity and group velocity.(U) **CSO 1.16:** To define wave amplitude and wave function. (K) **CSO 1.17:** To understand the significance of wave function in quantum mechanics.(U)	8	18	Not to be filled-in
UNIT 2 Heisenberg uncertainty principle	Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg	**CSO 2.1:** To understand the challenges in precisely measuring the position of particles.(U) **CSO 2.2:** To analyse the limitation posed by the wavelength of the probing radiation i.e.,	10	20	Not to be filled-in

	uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle-application to Size and structure of atomic nucleus, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle	gamma rays in the context of position measurement.(A) **CSO 2.3:** To explain the concept of wave-particle duality. (U) **CSO 2.4:** To understand the particles exhibit both wave-like and particle-like characteristics.(U) **CSO 2.5:** To derive the Heisenberg uncertainty principle involving canonical pairs of variables.(A) **CSO 2.6:** To understand the limitation in simultaneously measuring certain pairs of conjugate variables.(U) **CSO 2.7:** To understand how the uncertainty principle arises from the concept of wave packets.(U) **CSO 2.8:** To discuss the implications of the uncertainty principle on the predictability of a particle's trajectory.(U) **CSO 2.9:** To apply the uncertainty principle to estimate the minimum energy of a confined particles.(A) **CSO 2.10:** To understand the connection between position uncertainties and energy uncertainties.(U) **CSO 2.11:** To derive the energy-time uncertainty principles.(A) **CSO 2.12:** To apply energy-time uncertainty principle to analyse the size and structure of an atomic nucleus.(A) **CSO 2.13:** To discuss the implications of the uncertainty principle on the probability of finding an electron inside the nucleus.(U) **CSO 2.14:** To understand the role of quantum mechanical probabilities in describing the electrons position within an atom.(U)			
UNIT 3 **Schrodinger equation for non-relativistic particles;**	Two slit interference experiment with photons, atoms and particles; linear superposition principle	**CSO 3.1:**To understand the concept of interference in the context of the two-slit experiment.(U) **CSO 3.2:**To explore how	9	20	Not to be filled-in

probabilities and normalization.	as a consequence; Matter waves and wave amplitude; Schrodinger equation for nonrelativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension	interference patterns differ when conducting the experiment with photons, atoms and particles.(A) **CSO 3.3:**To define and understand the linear superposition principle.(K) **CSO 3.4:**To explain the concept of matter waves.(U) **CSO 3.5:**To understand wave amplitude and its significance in describing the behaviour of particles at the quantum level.(U) **CSO 3.6:**To derive Schrodinger equation for nonrelativistic particles.(A) **CSO 3.7:**To understand the mathematical framework that describe the evolution of wave functions in quantum mechanics.(U) **CSO 3.8:**To define momentum and energy operators in the context of quantum mechanics.(K) **CSO 3.9:**To explore the concept of stationary states and their significance in Schrodinger's equations.(A) **CSO 3.10:**To discuss the physical interpretation of wave functions.(U) **CSO 3.11:**To understand how probabilities are related to the square of the wave functions.(U) **CSO 3.12:**To define probability density and probability current density.(K) **CSO 3.13:** To explore the concept of probability density in one dimension and its relationship to the wave function.(A)			
UNIT 4 **Quantum tunnelling and nuclear force**	One dimensional infinitely rigid box-energy eigenvalues and Eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension across a step potential &	**CSO 4.1:**To understand the concept of an infinitely rigid box in quantum mechanics.(U) **CSO 4.2:**To calculate energy eigenvalues and eigenfunctions for a particle confined in a one-dimensional box.(A) **CSO 4.3:**To discuss the normalization wave function.(U) **CSO 4.4:**To explain the concept of quantum dots.(U)	8	20	Not to be filled-in

	rectangular potential barrier. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.	**CSO 4.5:**To analyse quantum mechanical scattering phenomena.(A) **CSO 4.6:**To understand tunnelling through potential barriers, both step potential and rectangular potential.(U) **CSO 4.7:**To explore the nature of nuclear forces and their role in atomic nuclei.(A) **CSO 4.8:**To understand the NZ graph, which represents the number of neutrons versus photons in stable nuclei. (U) **CSO 4.9:**To discuss the Liquid drop model as a representation of nuclear structure.(U) **CSO 4.10:**To explore the semi-empirical mass formula and understand its components including binding energy.(A) **CSO 4.11:**To explain nuclear shell model.(U) **CSO 4.12:**To understand the concept of magic numbers and their significance in the stability of atomic nuclei.(U) **CSO 4.13:**To discuss how the shell model explains certain nuclear properties.(U)			
UNIT 5 Radioactive and laser concept	Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments	**CSO 5.1:**To understand the factors influencing the stability of atomic nuclei.(U) **CSO 5.2:**To explain the concept of radioactive decay and its relation to radioactive decay.(U) **CSO 5.3:**To discuss the law of radioactive decay.(U) **CSO 5.4:**To define and calculate mean life and half-life of radioactive substance.(K) **CSO 5.5:**To explain the process of alpha decay.(U) **CSO 5.6:**To discuss energy released in beta decay.(U) **CSO 5.7:**To explore the beta decay spectrum and the role neutrons, as predicted by Pauli.(A) **CSO 5.8:**To understand the emission if gamma rays in nuclear processes.(U)	10	22	Not to be filled-in

	nd emission of neutrons. Nuclear eactor: slow neutrons nteracting with Jranium 235; Fusion nd thermonuclear eactions driving tellar energy (brief ualitative discussions). Lasers: Einstein's A nd B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.	**CSO 5.9:**To discuss the principle of energy-momentum conservation in gamma decay.(U) **CSO 5.10:**To explain the process of electron-positron pair creation by gamma photons.(U) **CSO 5.11:**To explain the concept of mass deflect in nuclear reaction.(U) **CSO 5.12:**To understand the role of relativity in explaining mass-energy equivalence.(U) **CSO 5.13:**To explore the generation of energy in nuclear fission and fusion reaction.(A) **CSO 5.14:**To describe the nature if fragments produced in nuclear fission.(K) **CSO 5.15:**To understand the significance of neutron emission in fission reaction.(U) **CSO 5.16:**To explain the basic principle if nuclear reactor.(U) **CSO 5.17:** To understand the role of sloe neutron in sustaining a chain reaction in uranium-235.(U) **CSO 5.18:** To discuss fusion reactions and their role in stellar energy production.(U) **CSO 5.19:** To understand the principles of Einstein's A and B coefficients in laser physics.(U) **CSO 5.20:** To discuss the concept of metastable states in laser.(U) **CSO 5.21:** To define and differentiate between spontaneous and stimulated emission.(K) **CSO 5.22:** To explain the process of optical pumping and its role in achieving population inversion.(U) **CSO 5.23:**To understand the operation of three-level and four-level laser.(U) **CSO 5.24:** To discuss specific examples such as the ruby laser and He-Ne laser.(U) **CSO 5.25:** To explain the basic principle of lasing, including stimulated emission and feedback.(U)			

SUGGESTED READINGS:

1. Arthur Beiser, *Concepts of Modern Physics*, McGraw-Hill, 2002.
2. Rich Meyer, Kennard, Coop, *Introduction to Modern Physics*, Tata McGraw Hill, 2002.
3. David J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2005.
4. Jewett and Serway, *Physics for scientists and Engineers with Modern Physics*, Cengage Learning, 2010.
5. G.Kaur and G.R. Pickrell, *Modern Physics*, McGraw Hill, 2014.
6. A.K.Ghatak&S.Lokanathan, *Quantum Mechanics: Theory & Applications*, Macmillan, 2004.
7. J.R. Taylor, C.D. Zafiratos, M.A. Dubson, , 2004, PHI Learning, 2004.
8. E.H.Wichman, *Quantum Physics*, Berkeley Physics, Vol.4, Tata McGraw-Hill Co., 1971.

Semester	IV
Paper Code	PHC 4.2(P)
Paper Title	Elements of Modern Physics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Sessions on the construction and use of specific measurement instruments and experimental apparatus used in the modern physics lab, including necessary precaution. Application to the specific experiments done in the lab.

1. Measurement of Planck‘s constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck‘s constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the value of e/m by Magnetic focusing/ Bar magnet or by any suitable method.
7. To setup the Millikan oil drop apparatus and determine the charge of an electron.
8. To show the tunnelling effect in tunnel diode using I-V characteristics.
9. To determine the wavelength of laser source using diffraction of single slit.
10. To determine the wavelength of laser source using diffraction of double slits.

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House, 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers, 1985.
3. I.Prakash& Ramakrishna, *A Text Book of Practical Physics*, 11th Edn,Kitab Mahal, 2011.

Semester	IV
Paper Code	PHC 4.3
Paper Title	Digital Systems and Applications
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Digital System and its Application**:

CO 1:	To make the student aware of concepts of Integrated Circuits, Digital Fundamentals and Basic Logic gates
CO 2:	To assist the students in problem solving using the idea of Boolean algebra and also get acclimatise to Arithmetic Circuits
CO 3:	To create an awareness among the students in Data processing circuits, Sequential Circuits and Counters and solve problems accordingly
CO 4:	To inculcate the idea in the working and application of Timer, Shift registers and Computer Organization
CO 5:	To make the students understand the various Digital Logic Families

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Integrated Circuits, Digital Fundamentals and Basic Logic gates	**Integrated Circuits**: Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs with examples **Digital Fundamentals**: Binary, Octal and Hexadecimal number systems and their inter conversion, Binary arithmetic (addition, subtraction, multiplication and	**CSO 1.1:** To define integrated circuit (K) **CSO 1.2:** To define and discuss on types of components: Active, passive and discrete components (K+U) **CSO 1.3:** To explain on the advantages and disadvantages of IC. (U) **CSO 1.4:** To introduce on the idea if scale of integration (U) **CSO 1.5:** To discuss on various types of ICs with proper examples (U) **CSO 1.6:** To explain, understand and examine the structure of various number systems and its application in digital design. (K+U+A) **CSO 1.7:** To define and explain the various logic gates (K+U) **CSO 1.8:** To solve and Design circuits based on the logics gates mentioned above (A)	8	18	Not to be filled-in

	division). **Basic Logic gates:** OR, AND, NOT, NOR XOR, XNOR, positive and negative logic				
UNIT 2 Boolean algebra and Arithmetic Circuits	**Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/ Subtractor.	**CSO 2.1:** To define Boolean algebra (K) **CSO 2.2:**Define and explain De Morgan's theorem (K+U) **CSO 2.3:** To work out problems based on the theorem (A) **CSO 2.4:** To discuss on various Boolean laws (K) **CSO 2.5:** To explain on how to use these laws to solve digital equations and design circuits. **CSO 2.6:** To introduce the idea of Minterms and Maxterms (K+U) **CSO 2.7:** To formulate digital equations using minterms and maxterms provided (A) **CSO 2.8:** To introduce on how to make digital circuits based on an equation provided or vice versa (K+A) **CSO 2.9:** To define and explain the concept of Karnaugh Map (K+U) **CSO 2.10:** To solve digital logic circuit problems based on K-Map (A) **CSO 2.11:** To introduce the idea on binary addition, binary subtraction with proper examples (K+U+A) **CSO 2.12:** To define 2's complement (K) **CSO 2.13:** To work out problems based on 2's complement (A) **CSO 2.14:** To define half adder, full adder, half subtrators, full subtractors (K) **CSO 2.15:** To discuss on how to design the various circuits mentioned above and its applications (A+U)	9	20	Not to be filled-in
UNIT 3 Data processing circuits, Sequential Circuits and Counters	Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge	**CSO 3.1:** To define data processing (K) **CSO 3.2:** To define and discuss on multiplexers, de-multiplexers, decoders and encoders with proper circuit design and circuit breakup. (K+U+A) **CSO 3.3:** To define sequential circuit (K) **CSO 3.4:** To define flip-flop (K)	11	24	Not to be filled-in

	Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **Counters (4 bits):** Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.	**CSO 3.5:** To define and explain on SR, D, JK and MS flip-flop with proper circuit designs and its breakups (K+U+A) **CSO 3.6:** To introduce the idea on clear, preset and clock (K) **CSO 3.7:** To define and explain race around condition and its importance in flip-flop (K+A) **CSO 3.8:** To define counters (K) **CSO 3.9**: To discuss on types of counters. (U) **CSO3.10:** To Explain and solve problems with ripple diagrams (U+A)			
UNIT 4 **Timers, Shift registers and Computer Organization**	**Timers**: IC 555: block diagram and applications: A stable multi vibrator and Mono stable multi vibrator. **Shift registers:** Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.	**CSO 4.1:** To define Time 555 (K) **CSO 4.2:** To elaborate on the block diagram and symbolic diagram of timer ic555 (U) **CSO 4.3:** To discuss on the working of timer ic555 and its various applications. (A) **CSO 4.4:** To define shift register (K) **CSO 4.5:** To Discuss in detail the different types and working of various Shift registers (U) **CSO 4.6:** To explain on how to translate ripple diagrams from the registers and make sense out of it. (A) **CSO 4.7:** To discuss on various input and output devices in computers (K) **CSO 4.8:** To Define storage in computer (K) **CSO 4.9:** To explain the types of storage (RAM, ROM) (U) **CSO 4.10:** To discuss the basic idea in memory addressing, memory interfacing and memory map (U)	9	20	Not to be filled-in
UNIT 5 **Digital Logic Families**	**Digital Logic Families:** Introduction and performance criteria for logic families, various logic families: DCTL, RTL, TTL and ECL working and characteristics	**CSO 5.1:** To introduce the idea of digital logic family(K+U) **CSO 5.2:** To Discuss on the various logic families and its performance criteria (U) **CSO 5.3:** To discuss with proper diagram the working of DCTL, RTL, TTL and ECL (U+A) **CSO 5.4:** To Explain on saturated and non-saturated logic families (U)	8	18	Not to be filled-in

	features, Saturated and non-saturated, fan in and fan out, MOS gates and CMOS gate, comparison of various logic families	**CSO 5.5:** To discuss on the difference between fan in and fan out (U) **CSO 5.6:** To Introduce the idea of MOS and CMOS gate (K) **CSO 5.7:** To bring out a comparison table of the logic families(U+A)			

SUGGESTED READINGS:

1. A.P. Malvino, D.P.Leach and Saha, *Digital Principles and Applications*, 7 Ed., Tata McGraw, 2011.
2. Anand Kumar, *Fundamentals of Digital Circuits*, 2ndEdn, PHI Learning Pvt. Ltd., 2009.
3. Venugopal, *Digital Circuits and systems*, Tata McGraw Hill, 2011.
4. G K Kharate,*Digital Electronics*,Oxford University Press, 2010.
5. R.J.Tocci, N.S.Widmer, *Digital Systems: Principles & Applications*, PHI Learning, 2001.
6. Shimon P. Vingron, *Logic circuit design*, Springer, 2012.
7. SubrataGhoshal, *Digital Electronics*, Cengage Learning, 2012.
8. S.K. Mandal, *Digital Electronics*, 1st edition, McGraw Hill, 2010.

Semester	IV
Paper Code	PHC 4.3(P)
Paper Title	Digital Systems and Applications
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The Objective of the laboratory is to present concepts and techniques in designing, realizing , debugging and documenting digital circuits and systems.

1. To measure (a) Voltage, and (b)Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit. Half Adder, Full Adder and 4-bit binary Adder. Half Subtractor, Full Subtractor, Adder
8. To build JK Master-slave flip-flop using Flip-Flop ICs
9. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
10. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
11. To design an a stable multivibrator of given specifications using 555 Timer.
12. To design a monostable multivibrator of given specifications using 555 Timer.

SUGGESTED READINGS:

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

Semester-V

Semester	V
Paper Code	PHC 5.1
Paper Title	Quantum Mechanics –I
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Quantum Mechanics I**:

CO 1:	To make the students aware of the failures in Classical Mechanics that led to the development of Quantum Mechanics
CO 2:	To aid the students in the understanding of the basis of Linear spaces that are required for Quantum Mechanics
CO 3:	To introduce the notations and different type of operators and how they are represented in matrix.
CO 4:	To make the students understand the Schrodinger wave equation.
CO 5:	To assist the students in the understanding of one-dimensional problems.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Introduction to Quantum Mechanics	Black body radiation, Plank hypothesis, Specific heat of solids, Photoelectric effect, Compton effect, Classical atomic structure models, Bohr's theory of Hydrogen spectrum, Stern - Gerlach Experiment, Heisenberg's uncertainty relation, wave- particle duality, Inadequacy of classical physics.	**CSO 1.1:** To identify the limitations of Classical mechanics in explaining Black Body Radiation(K) **CSO 1.2:** To explain the need for Plank's Hypothesis(U) **CSO 1.3:** To identify the limitations of Classical mechanics in explaining specific heat of solids. (U) **CSO 1.4:** To discuss the Photoelectric effect. (U) **CSO 1.5:** To discuss the Compton effect. (U) **CSO 1.6:** To recall the classical atomic structure models. (K) **CSO 1.7:** To examine and derive the hydrogen spectrum(A) **CSO 1.8:** To evaluate the importance of Stern-Gerlach experiment. (A) **CSO 1.9:** To understand the Heisenberg's uncertainty principle. (U) **CSO 1.10:** To recall the wave-particle duality(K) **CSO 1.11:** To identify the inadequacy of classical physics. (K)	8	18	Not to be filled-in

UNIT 2 Linear Spaces	Vector spaces and subspaces, Linear dependence and independence, Basis and dimensions, Linear operators, Inverses, Matrix representation, Similarity Transformations, Eigen values and eigen vectors, Norm and inner product, Cauchy-Schwarz inequality, Orthogonality, introduction only to Gramm-Schmidt Orthogonalization procedure	**CSO 2.1:** To explain vector spaces and sub spaces(U) **CSO 2.2:** To define linear dependence and independence. (K) **CSO 2.3:** To explain basis and dimensions. (U) **CSO 2.4:** To recall linear operators(K) **CSO 2.5:** To recall matrix representation. (K) **CSO 2.6:** To apply Newton's method to solve some Transcendental and polynomial equations. (A) **CSO 2.7:** To express similarity transformations. (A) **CSO 2.8:** To explore eigen vales and eigen vectors(A) **CSO 2.9:** To discuss norm and inner product(U) **CSO 2.10:** To analyse Cauchy-Schwarz inequality. (A) **CSO 2.11:** To describe Orthogonality. (K) **CSO 2.12:** To classify Gramm-Schmidt Orthogonalization procedure.	7	16	Not to be filled-in
UNIT 3 Operators	Introduction to Hilbert space, Dirac's Bra and Ket notations, quantum mechanical operators and observables, different types of operators-linear operator, Hermitian operator, parity operator, projection operator, Identity operator, Reflection operator and Unitary operator, Unitary Transformation, matrix representation of operator, change of basis, commutation relations for orbital angular momentum, eigen function of angular momentum operators, matrix representation of	**CSO 3.1:** To describe Hilbert space. (K) **CSO 3.2:** To classify Dirac's Bra and Ket notations. (U) **CSO 3.3:** To construct quantum mechanical operators and observables. (A) **CSO 3.4:** To discuss different types of operators such as linear operator, Hermitian operator, Parity operator, Projection operator, Identity operator, Reflection operator and Unitary operator. (U) **CSO 3.5:** To explain unitary transformations. (U) **CSO 3.6:** To elaborate matrix representation of operator. (U) **CSO 3.7:** To describe change of basis. (K) **CSO 3.8:** To explore commutation relations for orbital angular momentum. (A) **CSO 3.9:** To derive eigen function of angular momentum operators. (A) **CSO 3.10:** To illustrate matrix representation of angular momentum operators. (A)	10	22	Not to be filled-in

	angular momentum operators.				
UNIT 4 **Schrödinger wave equation**	Development of wave equation- Schrödinger time-independent and dependent wave equation, Ehrenfest theorem, postulates of quantum mechanics, solution of time dependent Schrödinger equation, properties of wave function, interpretation of wave function, Probability and probability current densities in three dimensions condition for physical acceptability of wave function, Normalization.	**CSO 4.1:** To investigate the development of Schrodinger time-independent and dependent wave equation. (A) **CSO 4.2:** To examine Ehrenfest theorem. (A) **CSO 4.3:** To explain postulates of quantum mechanics. (U) **CSO 4.4:** To discuss solution of time dependent Schrodinger equation. (U) **CSO 4.5:** To describe the properties of wave function. (K) **CSO 4.6:** To analyse the interpretation of wave function. (A) **CSO 4.7:** To discuss probability and probability current densities in three dimensions conditions for physical acceptability of wave function. (U) **CSO 4.8:** To discuss Normalization. (U)	10	22	Not to be filled-in
UNIT 5 One dimensional problem	Particle in one dimension: boundary conditions at the surface of infinite potentials, infinite potential well, finite potential well, linear harmonic oscillator: Schrodinger's method and Operator method.	**CSO 5.1:** Todiscuss particle in one dimension with boundary conditions at the surface of infinite potential. (U) **CSO 5.2:** To analyse particle in one-dimension infinite potential well. (A) **CSO 5.3:** To analyse particle in one dimension finite potential well. (A) **CSO 5.4:** To discuss Linear Harmonic Oscillator. (U) **CSO 5.5:** To derive Linear Harmonic Oscillator using Schrodinger and Operator method. (A)	9	20	Not to be filled-in

SUGGESTED READINGS:

1. P.M.Mathews and K.Venkatesan, *A Text book of Quantum Mechanics*, 2nd Ed., McGraw Hill, 2010.
2. Leonard I. Schiff, *Quantum Mechanics*, 3rd Edn., Tata McGraw Hill, 2010.
3. Bruce Cameron Reed, *Quantum Mechanics*, Jones and Bartlett Learning, 2008.
4. Arno Bohm, *Quantum Mechanics: Foundations & Applications*, 3rd Edn., Springer, 1993.
5. D.A.B. Miller, *Quantum Mechanics for Scientists & Engineers*, Cambridge University Press, 2008.
6. Eugen Merzbacher, *Quantum Mechanics*, John Wiley and Sons, Inc., 2004.
7. D.J. Griffith, *Introduction to Quantum Mechanics*, 2nd Ed., Pearson Education, 2005.
8. Walter Greiner, *Quantum Mechanics*, 4th Edn., Springer, 2001.
9. Nourendine Zettili, *Quantum Mechanics concepts and applications*, 2nd Edition, Wiley, 2009.

Semester	V
Paper Code	PHC 5.1(P)
Paper Title	Quantum Mechanics-I
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

With the exposure in computer programming and computational techniques, the student will be in a position to perform numerical simulations for solving the problems based on Quantum Mechanics.

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

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

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E] \text{ where } V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(\text{eVÅ})^{1/2}$, ħc = 1973 (eVÅ) and m = $0.511\text{x}10^6$ eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(\text{eVÅ})^{1/2}$, m = $0.511\text{x}10^6$ eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For the anharmonic oscillator potential

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

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100

Laboratory based experiments:

4. StudyofElectronspinresonance-determinemagneticfieldasafunctionoftheresonance frequency
5. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
6. To show the tunneling effect in tunnel diode using I-V characteristics.
7. Quantum efficiency of CCDs

SUGGESTED READINGS:

1. J.Hubbard, *Schaum's outline of Programming with C++*,McGraw HillPublication, 2000.
2. W.H.Pressetal., *Numerical RecipesinC:The Art of Scientific Computing*,3rd Edn.,Cambridge University Press, 2007.
3. T.Pang,*An introduction to computational Physics*, 2ndEdn., CambridgeUniv.Press, 2006.
4. A.Vande Wouwer, P.Saucez,C.V.Fernández, *Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications*, Springer, 2014.
5. H.Ramchandran,A.S.Nair, *Scilab(A Free Software to Matlab)*, S.Chand&Co, 2011.
6. L.M.Surhone, *ScilabImage Processing*, Beta script Publishing ISBN:978-6133459274, 2010.

Semester	V
Paper Code	PHC 5.2
Paper Title	Classical Dynamics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Classical Dynamics**:

CO 1:	To understand the Newtonian, the Lagrangian and the Hamiltonian formulation of classical mechanics and their applications in appropriate physical problems.
CO 2:	To understand the Hamiltonian formalism.
CO 3:	To understand the small oscillation problems.
CO 4:	To understand the fundamental concepts of special theory of relativity and their physical consequences.
CO 5:	To understand the basics of fluid dynamics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Classical Mechanics Lagrangian formalism	Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and	**CSO 1.1:** To define classical mechanics.(K) **CSO 1.2:** To revise the knowledge of the Newtonian and learn its application to electric and magnetic fields.(A) **CSO 1.3:** To study the motion of a charged particle in crossed electric and magnetic fields. (U) **CSO 1.4:** To define constraints and	13	20	Not to be filled-in

	gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and ve-locities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity	learn the different types of constraints.(K) **CSO 1.5:** To understand the fundamental concepts of analytical mechanics such as generalized coordinates and velocities.(U) **CSO 1.6:** To define and explain the Hamilton's principle.(K&U) **CSO 1.7:** To derive the Hamilton's principle from D'Alembert's principle.(A) **CSO 1.8:** To derive the Lagrange's equation from Hamilton's principle.(A) **CSO 1.9:** To explain the Euler-Lagrange equation.(U)			
UNIT 2 Hamiltonian Formalism	Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momen-tum and energy.	**CSO 2.1:** To define generalised momentum and find the expression for it.(K) **CSO 2.2:** To define cyclic coordinates. (K) **CSO 2.3:** To Obtain the Hamiltonian (H) value.(U) **CSO 2.4:** To derive the Hamilton's equation of motion.(A) **CSO 2.5:** To define harmonic oscillator.(K) **CSO 2.6:** To derive the Hamiltonian for a harmonic oscillator. (A) **CSO 2.7:** To find the Hamilton's equation of motion for a particle under central forces.(A) **CSO 2.8:** To find the Hamilton's equation of motion in polar cylindrical coordinates. (A) **CSO 2.9:** To derive the Hamilton's equation of a simple pendulum.(A) **CSO 2.11:** To find the Hamilton's equation of motion in spherical cylindrical coordinate system. (A)	11	20	Not to be filled-in
UNIT 3 Small Amplitude Oscillations	Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses	**CSO 3.1:** To explain small amplitude oscillations in brief.(K) **CSO 3.2:** To define equilibrium and its types.(K) **CSO 3.3:** To explain stability analysis. (U) **CSO 3.4:** To explain the stability of a simple pendulum(one dimensional oscillator).(U) **CSO 3.5:** To explain general problems of small oscillations.(U) **CSO 3.6:** To explain eigen	12	20	Not to be filled-in

	connected in a linear fashion to (N -1) - identical springs.	frequencies and eigen vectors.(U) **CSO 3.7:** To show that the eigen vectors are orthogonal.(U) **CSO 3.8:** To explain normal coordinates.(U) **CSO 3.9:** To derive the energy value using the concept of normal coordinates.(A)			
UNIT 4 **Special Theory of Relativity**	Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Four-momentum and energy-momentum relation.	**CSO 4.1:** To state the postulates of special theory of relativity. (K) **CSO 4.2:** To define Lorentz transformations and derive its equations.(K&A) **CSO 4.3:** To understand what Minkowski space is.(U) **CSO 4.4:** To explain space time interval and prove that it is invariant under a Lorentz transformation.(U) **CSO 4.5:** To explain the classification of space time interval.(U) **CSO 4.6:** To explain time dilation and length contraction and solve numerical problems based on both.(U&A) **CSO 4.7:** To derive the equation for the momentum four vector.(A) **CSO 4.8:** To deduce the velocity four vector.(A) **CSO 4.9:** To deduce the acceleration four vector.(A) **CSO 4.10:** To derive the energy-momentum relation.(A)	15	23	Not to be filled-in
UNIT 5 Fluid Dynamics	Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.	**CSO 5.1:** To define fluid and learn the characteristics of fluid.(K) **CSO 5.2:** To define density and pressure and learn the relationship between them.(K) **CSO 5.3:** To learn the different types of fluid flow.(U) **CSO 5.4:** To derive the continuity equation.(A) **CSO 5.5:** To derive the Navier Stokes equation of motion.(A) **CSO 5.6:** To define and explain Reynolds' number .(K&A) **CSO 5.7:** To solve numerical problems using Reynolds' number(A) **CSO 5.8:** To state the assumptions and derive the Poiseuille's equation of motion.(A)	9	17	Not to be filled-in

		CSO 5.9: To give the qualitative description of turbulence. (U)			

SUGGESTED READINGS:

1. H.Goldstein, C.P. Poole, J.L. Safko, *Classical Mechanics*, 3rd Edn., Pearson Education, 2002.
2. L. D. Landau and E. M. Lifshitz, *Mechanics*, Pergamon, 1976.
3. J.D. Jackson, *Classical Electrodynamics*, 3rd Edn., Wiley, 1998.
4. L.D Landau, E.M Lifshitz, *The Classical Theory of Fields*, 4th Edn., Elsevier, 2003.
5. D.J. Griffiths, *Introduction to Electrodynamics*, Pearson Education, 2012.
6. R. Douglas Gregory, *Classical Mechanics*, Cambridge University Press, 2015.
7. Dieter Strauch, *Classical Mechanics: An introduction*, Springer, 2009.
8. O.L. Delange and J. Pierrus, *Solved Problems in classical Mechanics*, Oxford Press, 2010.

Semester	V
Paper Code	PHC 5.3
Paper Title	Solid State Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Solid state physics**:

CO 1:	To make the students understand the basic concept of the crystal structure.
CO 2:	To aid the students in the understanding of Elementary Lattice Dynamics.
CO 3:	To create an understanding among the students about different magnetic materials and their properties.
CO 4:	To inculcate and create interest among students in the understanding of Dielectric properties of materials and Ferroelectric Properties of Materials
CO 5:	To assist the students in the understanding of Elementary band theory and superconductors

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Crystal Structure	Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals.	**CSO 1.1:** To identify Amorphous and Crystalline Materials. (K) **CSO 1.2:** To describe lattice translations vectors. (K) **CSO 1.3:** To define basis and unit cell (K). **CSO 1.4:** To discuss Miller indices. (U) **CSO 1.5:** To discuss the concept of reciprocal lattice. (U) **CSO 1.6:** To classify different	9	20	Not to be filled-in

	Bragg's Law.	types of lattices. (U) **CSO 1.7:** To define the Brillouin zones and discuss its derivations. (K) **CSO 1.8:** To derive the diffraction of x-rays of crystals. (A) **CSO 1.9:** To define Bragg's law. (K) **CSO 1.10:** To construct the reciprocal lattice for simple cubic, face centered cubic and body centered cubic structure. (A) **CSO 1.11:** To differentiate between simple cubic, face centered cubic and body centered cubic structure **CSO 1.12:** To derive Bragg's equation. (A)			
UNIT 2 **Elementary Lattice Dynamics**	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law	**CSO 2.1:** To discuss the concept of lattice vibrations and phonons. **CSO 2.2:** To construct the lattice vibrational mode for monoatomic crystal. (A) **CSO 2.3:** To construct the lattice vibrational mode for diaoatomic crystal. (A) **CSO 2.4:** To define acoustical and optical phonons. (K) **CSO 2.5:** To discuss the description of the phonon spectrum in solids. (U) **CSO 2.6:** To state Dulong and Petit's Law. (K) **CSO 2.7:** To describe Einstein and Debye theories of specific heat of solids. (K) **CSO 2.8:** To derive the Dulong and Petit's law. (A) **CSO 2.9:** To construct Einstein theory of specific heat of solid. (A) **CSO 2.10:** To construct Debye theory of specific heat of solid. (A) **CSO 2.11:** To define T^3 law. (K) **CSO 2.12:** To derive the T^3 Law	8	19	Not to be filled-in
UNIT 3 **Magnetic properties of matter**	Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical	**CSO 3.1:** To define Dia, Para, Ferri and Ferromagnetic materials. (K) **CSO 3.2:** To derive the classical Langevin theory of Dia- and paramagnetic magnetism. (A) **CSO 3.3:** To analyse the quantum mechanical treatment of	8	19	Not to be filled-in

	Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve.	paramagnetism. (A) **CSO 3.4:** To state Curie's law. (K) **CSO 3.5:** To construct Weiss's theory of Ferromagnetism and Ferromagnetic domains. (A) **CSO 3.6:** To illustrate the B-H curve of ferromagnetic material. (A) **CSO 3.7:** To differentiate between Dia-, Para-, Ferri- and Ferromagnetic materials. (U) **CSO 3.8:** To define domains. (K)			
UNIT 4 **Dielectric properties of materials and Ferroelectric Properties of Materials**	**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. ClausiusMosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. **Ferroelectric Properties of Materials**: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Ferroelectric domains, PE hysteresis loop.	**CSO 4.1:** To define polarization. (K) **CSO 4.2:** To explain local electric field of an atom. (U) **CSO 4.3:** To define depolarization field. (k) **CSO 4.4:** To define electric susceptibility. (K) **CSO 4.5:** To define polarizability. (K) **CSO 4.6:** To derive and explain Clausius Mosotti equation. (A) **CSO 4.7:** To explain classical theory of electric polarizability. (U) **CSO 4.8:** To define and discuss normal and anomalous dispersion. (U) **CSO 4.9:** To construct Cauchy and Sellmeir relations. (A) **CSO 4.10:** To derive Langevin-Debye equation. (A) **CSO 4.11:** To discuss optical phenomena. (U) **CSO 4.12:** To describe plasma oscillations, plasma frequency, plasmons. (K) **CSO 4.13:** To define and explain ferroelectric properties of materials. (U)	11	22	Not to be filled-in

UNIT 5 Elementary band theory and superconductivity.	**Elementary band theory:** Kronig Penny model. Band Gap. Conductor, Semiconductor and insulator. Conductivity of Semiconductor, mobility, Hall Effect and Hall coefficient. **Superconductivity**: Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation. Isotope effect.	**CSO 5.1:** To define and explain the elementary band theory. (K) **CSO 5.2:** To construct Kronig Penny model. (A) **CSO 5.3:** To explain band gap. (U) **CSO 5.4:** To define conductor, semiconductor and insulator. (K) **CSO 5.5:** To explain the conductivity of semiconductor, mobility, hall effect and hall coefficient. (U) **CSO 5.6:** To define superconductivity. (A) **CSO 5.7:** To discuss critical temperature and critical magnetic field. (U) **CSO 5.8:** To discuss Meissner effect. (U) **CSO 5.9:** To derive London's equation. (A) **CSO 5.10:** To determine the Isotope effect of superconductors. (U)	9	20	Not to be filled-in

SUGGESTED READINGS:

1. Charles Kittel, *Introduction to Solid State Physics*, 8th Edition, Wiley India Pvt. Ltd, 2004.
2. J.P. Srivastava, *Elements of Solid State Physics*, 4th Edition, Prentice-Hall of India, 2015.
3. Leonid V. Azaroff, *Introduction to Solids*, Tata Mc-Graw Hill, 2004.
4. N.W. Ashcroft and N.D. Mermin, *Solid State Physics*, Cengage Learning, 1976.
5. H. Ibach and H. Luth, *Solid-state Physics*, Rita John, *Springer Solid State Physics*, McGraw Hill 2009, 2014.
6. 1/e M. Ali Omar, *Elementary Solid State Physics*, Pearson India, 1999.
7. M.A. Wahab, *Solid State Physics*, Narosa Publications, 2011.

Semester	V
Paper Code	PHC 5.3 (P)
Paper Title	Solid State Physics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The aim and objective of the lab course is to introduce the students to the formal structure of solid state physics so that they can use these as per their requirement.

1. Measurement of susceptibility of paramagnetic solution by (Quinck`s Tube Method)/suitable method.

2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Material by suitable method.
4. To study the PE Hysteresis loop of a Ferroelectric Crystal.
5. To draw the BH curve of Fe using Solenoid/transformer & determine energy loss from Hysteresis.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ◦C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House, 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers, 1985.
3. I. Prakash& Ramakrishna, *A Text Book of Practical Physics*, 11th Ed., Kitab Mahal, 2011.
4. J.P. Srivastava, *Elements of Solid State Physics*, 2nd Ed., Prentice-Hall of India, 2006.

Semester-VI

Semester	VI
Paper Code	PHC 6.1
Paper Title	Quantum Mechanics II
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Quantum Mechanics II**:

CO 1:	To make the students aware of the uncertainty relations and exactly solvable problems in three dimensions
CO 2:	To aid the students in the understanding of symmetry in quantum mechanics and the excited states of helium atom
CO 3:	To create an understanding among the students about the time independent perturbation and the variational method.
CO 4:	To inculcate and create interest among students in the understanding of time dependent perturbation and how it affects the absorption and emission of radiation.
CO 5:	To assist the students in the understanding of WKB approximation.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Uncertainty relation and exactly solvable problems in three dimensions	Uncertainty relations: Stern-Gerlach experiment and the concept of spin, Pauli-spin matrices, Addition of angular momentum: Clebsch-Gordan coefficients for two particles. Exactly solvable problems in three dimensions: Separation of Schrodinger equation in Cartesian coordinates, Simple harmonic oscillator in 3-dimensions, Free particle in 3-d box – Effects of the exclusion principle on non-interacting fermions in a box, central potential, Schrodinger equation in Spherical coordinates-separation of variables r, Φ, Θ. The hydrogen atom – radial equation; energy spectrum; degeneracy of the spectrum; radial wave functions and probability density P(r) for finding the electron at a distance from the centre; evaluation of expectation values of r^n .	CSO 1.1: To discuss the Stern-Gerlach experiment and the concept of spin(U) CSO 1.2: To describe the Pauli Spin matrices. (K) CSO 1.3: To determine Clebsch-Gordon coefficients for two particles(A) CSO 1.4: To separate Schrodinger equation in cartesian coordinates. (A) CSO 1.5: To elaborate simple harmonic oscillator in 3 D. (U) CSO 1.6: To construct the effects of the exclusion principle on non-interacting fermions in a box. CSO 1.7: To discuss central potential. (U) CSO 1.8: To derive Schrodinger equation in spherical coordinates and separation of variables r, Φ, Θ. (A) CSO 1.9: To evaluate the radial equation. (A) CSO 1.10: To outline the energy spectrum. (K) CSO 1.11: To determine radial wave functions and probability density P(r) for finding the electron at a distance from the centre. (A) CSO 1.12: To evaluate expectation values of r^n . (A)	15	25	Not to be filled-in
UNIT 2 Symmetry in quantum mechanics	Symmetry transformation, Spatial transition - conservation of linear momentum, Translation in time, Conservation of energy. Rotation in space-conservation of angular momentum. Discrete symmetries: parity and time reversal, Permutation symmetry: symmetric and anti-symmetric wave functions for two identical particles, slater	CSO 2.1: To describe symmetry transformation. (K) CSO 2.2: To describe spatial transition- conservation of linear momentum. (K) CSO 2.3: To describe spatial transition-. translation in time. (K) CSO 2.4: To describe spatial transition- conservation of energy. (K) CSO 2.5: To describe rotation in space- conservation of angular momentum. (K) CSO 2.6: To discuss discrete	12	22	Not to be filled-in

	determinant and Pauli exclusion principle, Exited states of helium atom: ortho and para helium atom.	symmetries: parity and time reversal. (U) CSO 2.7: To examine Permutation symmetry: symmetric and anti-symmetric wave functions for two identical particles. (A) CSO 2.8: To explore slater determinant and Pauli exclusion principle. (A) CSO 2.9: To analyse the rate of convergence for Newton's method. (A) CSO 2.10: To derive and examine excited states of Helium atom- Ortho and para helium atom. (A)			
UNIT 3 Time independent perturbation and the variational method	Time independent perturbation: Perturbation theory for non-degenerate states, Applications. linear and quadratic stark effects in hydrogen atom, validity of time independent perturbation theory, Degenerate perturbation theory, examples: linear stark effect, Normal Zeeman effect. The variational method: Variation principle, application of variational approach to ground states of (i) Hydrogen atom and (ii) Helium atom.	CSO 3.1: To construct perturbation theory of non-degenerate states. (A) CSO 3.2: To apply linear and quadratic stark effects in hydrogen atom. (A) CSO 3.3: To discuss validity of time independent perturbation theory. (U) CSO 3.4: To construct degenerate perturbation theory. (A) CSO 3.5: To apply Gauss Jordon method to solve some system of linear algebraic equations. (A) CSO 3.6: To explain Gauss Jacobi method and its derivative. (U) CSO 3.7: To investigate linear stark effect. (A) CSO 3.8: To explain normal Zeeman effect. (U) CSO 3.9: To explore variation principle. (A) CSO 3.10: To apply variational approach to ground states of hydrogen atom. (A) CSO 3.11: To apply variational approach to ground states of Helium atom. (A)	13	23	Not to be filled-in
UNIT 4 Time dependent perturbation theory	Time dependent perturbation series- transition probability, transition to the Continuum-Fermi golden rule, Harmonic perturbation, absorption and emission of radiation, Einstein's A and B coefficient, selection rules.	CSO 4.1: To derive time dependent perturbation series- transition probability. (A) CSO 4.2: To discuss transition to the continuum- Fermi golden rule. (U) CSO 4.3: To describe harmonic perturbation. (K) CSO 4.4: To analyse absorption and emission of radiation. (A) CSO 4.5: To examine Einstein's A and B coefficient.	10	15	Not to be filled-in

		CSO 4.6: To outline the selection rules. (K)			
UNIT 5 WKB Approximation	WKB method, the connection formulas, validity of WKB method, barrier penetration, Alpha emission, bound states in a potential well.	CSO 5.1: To describe WKB method. (K) CSO 5.2: To derive the connection formulas. (A) CSO 5.3: To discuss the validity of WKB method. (U) CSO 5.4: To explain barrier penetration. (U) CSO 5.5: To analyse alpha emission. (A) CSO 5.6: To discuss bound states in a potential well. (U)	10	15	Not to be filled-in

SUGGESTED READINGS:

1. B.H. Bransden and Joachain, *Quantum mechanics*,2 nd Edition Pearson Education, 2004.
2. NouredineZettili, *Quantum mechanics: concepts and applications*, 2nd Edition, Wiley, 2018.
3. David J. Griffiths, *Introduction to Quantum mechanics*,2nd Edition, Parson Education 2005.
4. J.J. Sakurai, *Modern Quantum mechanics*, Pearson Education, 2000.
5. V.KThankappan, *Quantum mechanics*, 2 nd Edition Pri, 2004.
6. E. Merzbacher, *Quantum Mechanics*, 3rd edition, John Wiley, 1994.
7. R. Shankar, *Principles of Quantum mechanics*,2 nd Edition, Premium press, NY, 1994.
8. J.D. Bjorken and S.D. Drell, *Relativistic Quantum mechanics and Relativistic Quantum fields*, Mc. Graw-hill,New York, 1968.
9. L.I.Schiff *Quantum mechanics*, Mc. Graw-hill, 1955.
10. C.Cohen-Tannoudji, B.Diu, F.Laloe, *Quantum Mechanics* (2 vol. set), Wiley Interscience, 1996.

Semester	VI
Paper Code	PHC 6.2
Paper Title	Nuclear and Particle Physics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Nuclear and Particle Physics**:

CO 1:	To understand the basic properties of the nucleus.
CO 2:	To analyse different nuclear models.
CO 3:	To make the students understand the concept of radioactivity and nuclear reactions.
CO 4:	To understand the working of nuclear detectors and counters.
CO 5:	To make the students understand the different types of particles and the conservation laws related to them.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 General Properties of Nuclei	Constituents of nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter energy), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states, concept of nuclear force.	**CSO 1.1:** To define nucleus.(K) **CSO 1.2:** To understand the constituents that made up a nucleus.(U) **CSO 1.3:** To learn the different intrinsic properties of the nucleus .(U) **CSO 1.4:** To define binding energy and explain its variation with mass number.(K&A) **CSO 1.5:** To discuss the classification of nuclei.(U) **CSO 1.6:** To understand the concept of nuclear force.(U)	11	18	Not to be filled-in
UNIT 2 Nuclear Models	Liquid drop model approach, Fermi gas model, semi empirical mass formula and significance of various terms, condition of nuclear stability, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model.	**CSO 2.1:** To explain the Liquid Drop model.(U) **CSO 2.2:** To explain the Fermi Gas model.(U) **CSO 2.3:** To explain the semi empirical mass formula and the significance of the various terms in the formula. (U) **CSO 2.4:** To explain the condition of nuclear stability.(U) **CSO 2.5:** To explain the evidence of nuclear shell structure. (U) **CSO 2.6:** To define magic numbers .(K) **CSO 2.7:** To explain the shell model using the concept of magic numbers. (U)	13	22	Not to be filled-in
UNIT 3 Radioactivity	(a) Alpha decay: basics of α-decay processes, qualitative idea of alpha emission theory, Geiger Nuttall law, (b) Beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics,	**CSO 3.1:** To define radioactivity .(K) **CSO 3.2:** To define radioactivity decay.(K) **CSO 3.3:** To define alpha, beta and gamma rays.(K) **CSO 3.4:** To define alpha decay.(K) **CSO 3.5:** To discuss the basics of alpha decay processes.(U) **CSO 3.6:** To discuss the qualitative idea of alpha emission theory.(U) **CSO 3.7:** To explain the Geiger Nuttal law.(U) **CSO 3.8:** To define beta decay.(K) **CSO 3.9:** To derive the energy kinematics	14	24	Not to be filled-in

	internal conversion. **Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate.	for different types of beta decay.(A) **CSO 3.10:** To explain the neutrino hypothesis.(U) **CSO 3.11:** To define gamma decay.(K) **CSO 3.12:** To explain the different types of gamma decay processes.(U) **CSO 3.13:** To define nuclear reactions.(K) **CSO 3.14:** To define the different types of nuclear reactions.(K) **CSO 3.15:** To discuss the conservation laws related to nuclear reactions.(U) **CSO 3.16:** To derive the Q-Value of nuclear reactions.(A)			
UNIT 4 **Detector for Nuclear Radiations**	Ionization chamber, proportional counter and GM Counter. Basic principle of Scintillation Detectors and construction of Photo-Multiplier Tube (PMT). **Particle Accelerators:** Van-de Graaff generator, Linear accelerator, Cyclotron	**CSO 4.1:** To define detector.(U) **CSO 4.2:** To explain the Ionization Chamber.(U) **CSO 4.3:** To explain the Proportional Counter.(U) **CSO 4.4:** To explain the GM Counter.(U) **CSO 4.5:** To explain Scintillation Detector.(U) **CSO 4.6:** To explain Photo Multiplier tube.(U) **CSO 4.7:** To define accelerators. (K) **CSO 4.8:** To explain Vande-Graff generator.(U) **CSO 4.9:** To explain Linear Accelerator. (U) **CSO 4.10:** To define Cyclotron. (K) **CSO 4.11:** To explain the Cyclotron. (U)	12	20	Not to be filled-in
UNIT 5 **Particle physics**	Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model.	**CSO 5.1:** To define particle Physics. (K) **CSO 5.2:** To define elementary particles. (K) **CSO 5.3:** To explain the classification of elementary particles. (U) **CSO 5.4:** To discuss the fundamental interactions associated with the elementary particles. (A) **CSO 5.5:** To explain the intrinsic quantum numbers associated with elementary particles. (U) **CSO 5.6:** To explain the conservation laws associated with the elementary particles. (U) **CSO 5.7:** To explain the symmetries related to conservation laws. (U) **CSO 5.8:** To define quark.(K) **CSO 5.9:** To explain the quark model. (U)	10	16	Not to be filled-in

SUGGESTED READINGS:

1. Kenneth S. Krane ,*Introductory nuclear Physics* ,Wiley India Pvt. Ltd., 2008.
2. Bernard L. Cohen ,*Concepts of nuclear physics*, Tata Mc graw Hill, 1998.
3. R.A. Dunlap, *Introduction to the physics of nuclei & particles*, Thomson Asia, 2004.
4. K. Heyde, *Basic ideas and concepts in Nuclear Physics - An Introductory Approach* ,IOP- Institute of Physics Publishing, 2004.
5. G.F. Knoll , *Radiation detection and measurement*, John Wiley & Sons, 2000.
6. J.M. Blatt &V.F.Weisskopf , *Theoretical Nuclear Physics*, Dover Pub.Inc., 1991.

Semester	VI
Paper Code	PHC 6.3
Paper Title	Electromagnetic Theory
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Electromagnetic theory**:

CO 1:	To make the students enabling them to analyse and solve complex problem relating to electromagnetic fields and their interaction and deep understanding of the theoretical concepts and the ability to apply them in practical situation.
CO 2:	To understand the electromagnetic wave propagation in different media, from vacuum and dielectric materials to conducting media and dilute plasma.
CO 3:	To create an understanding the law of governing the reflection and refraction of electromagnetic waves at dielectric interfaces and applying Fresnel's law and other relevant concept to solve ad analyse problems related to different interfaces between different media.
CO 4:	To create comprehensive understanding of polarization and propagation of electromagnetic waves in anisotropic media and solve problem related to various polarization phenomena and their applications in optics.
CO 5:	To make the student well-versed in the principles and analysis of planar optical waveguides and possess skills to design and analyse waveguide structures, understand the behaviour and evaluate the transmission of the system, understand their practical application in the field of optical waveguide technology.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Maxwell Equations	Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and	**CSO 1.1:** To understand and ability to state Maxwell's equations in integral and differential forms.(U) **CSO 1.2:** To apply Maxwell's equations to analyse electromagnetic phenomena.(A) **CSO 1.3:** To describe the concept of displacement current and its role in modifying Ampere's law.(K) **CSO 1.4:** To express electromagnetic fields in terms of vector and scalar potentials.(A) **CSO 1.5:** To understand the advantages and application of using potentials in problem solving.(U) **CSO 1.6:** To identify the use of Lorentz Coulomb gauge	10	21	Not to be filled-in

	Angular Momentum Density.	transformations.(K) **CSO 1.7:** To understand the ability to choose appropriate gauge transformation based on specific problem requirements.(U) **CSO 1.8:** To understand the application of Maxwell's equation to derive boundary conditions.(U) **CSO 1.9:** To apply in solving problems involving interfaces between different electromagnetic media.(A) **CSO 1.10:** To derive and solve wave equation for electromagnetic fields.(A) **CSO 1.11:**To analyse propagation of electromagnetic waves.(A) **CSO 1.12:** To understand the behaviour of plane waves in dielectric media.(U) **CSO 1.13:** To calculate and analyse the properties of electromagnetic waves in different media.(A) **CSO 1.14:** To understand Poynting theorem as a statement of conservation of energy for electromagnetic fields.(U) **CSO 1.15:** To calculate Poynting vector and its application.(A) **CSO 1.16:** To explain electromagnetic energy density and its significance.(U) **CSO 1.17:** To explain electromagnetic energy densityin problem solving.(U) **CSO 1.18:** To understand the physical interpretation of electromagnetic field energy density, momentum density and angular momentum density.			
UNIT 2 **EM Wave Propagation in Unbounded Media**	Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin	**CSO 2.1:** To understand the fundamental properties of plane electromagnetic waves in vacuum.(U) **CSO 2.2:** To analyse the behaviour of electromagnetic waves when passing through isotropic dielectric media.(A) **CSO 2.3:** To calculate and interpret changes in wave parameters. (A)	8	21	Not to be filled-in

	depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	**CSO 2.4:** To explain the transverse nature of electromagnetic waves.(U) **CSO 2.5:** To apply transverse waves properties in analysing polarization and related phenomena.(A) **CSO 2.6:** To understand the concept of refractive index and dielectric constant in the context of electromagnetic wave propagation.(U) **CSO 2.7:** To calculate and interpret refractive indices and dielectric constants for different materials(A) **CSO 2.8:** To calculate and understand wave impedance.(A) **CSO 2.9:** To applywave impedance concepts in analysing the interaction of electromagnetic waves with different medium.(A) **CSO 2.10:** To understand the challenges and characteristics of electromagnetic wave propagation through conducting media.(U) **CSO 2.11:** To analyse electrical conductivity, relaxation time and skin depth in conducting media.(A) **CSO 2.12:** To calculate relaxation time and skin depth.(A) **CSO 2.13:** To apply the concept in understanding the attenuation of electromagnetic waves in conducting media.(A) **CSO 2.14:** To understand the unique properties of electromagnetic wave propagation through dilute plasma.(U) **CSO 2.15:** To explain the electrical conductivity in ionized gases. (U) **CSO 2.16:** To apply conductivity concept in understanding the behaviour of electromagnetic waves in ionized gases.(A) **CSO 2.17:** To calculate and understand the role of plasma frequency in determining the behaviour of electromagnetic waves in plasma. (A)			

		CSO 2.18: To apply the concept to analyse the propagation of electromagnetic waves through the ionosphere. (A) **CSO 2.18:** To understand the practical implication of wave propagation in the earths ionosphere.(U)			
UNIT 3 **EM Wave in Bounded Media**	Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal re-flection, evanescent waves. Metallic reflection (normal Incidence).	**CSO 3.1:** To apply Maxwell's equations to derive boundary conditions at interfaces (A) **CSO 3.2:** To calculate problems relating to the interaction of electromagnetic waves at a plane interface between two media.(A) **CSO 3.3:** To understand the fundamental principles governing the reflection and refraction of plane waves.(U) **CSO 3.4:** To apply the principles to analyse the behaviour of electromagnetic waves at interfaces between dielectric media.(A) **CSO 3.5:** To state and apply the law of reflection and refraction for plane waves at a dielectric interface.(K) **CSO 3.6:** To derive the incident, reflected and transmitted angles in terms of wave vectors.(A) **CSO 3.7:** To understand the Fresnel's formula and calculate for both perpendicular and parallel polarization..(U) **CSO 3.8:** To understand Brewster's law and its significance of reflection and refraction and determine the angle of incidence for which reflection is minimized.(U) **CSO 3.9:** To calculate reflection and transmission coefficients for plane waves at dielectric interface and interpret in terms of waves amplitude and intensity.(A) **CSO 3.10:** To understand the conditions and consequences of total internal reflection and application of critical concepts in the context of total internal reflection.(U)	9	20	Not to be filled-in

		CSO 3.11: To explain evanescent waves and their role in total internal reflection and apply the concept in specific scenario.(U) **CSO 3.12:** To understand the behaviour of electromagnetic waves when incident on a metallic surface at normal incidence and apply the concept in practical situation.(U)			
UNIT 4 **Polarization of Electromagnetic Waves; Rotatory Polarization**	Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel‘s Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light **Rotatory Polarization:** Optical Rotation. Biot‘s Laws for Rotatory Polarization. Fresnel‘s Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent‘s half-shade polarimeter.	**CSO 4.1:** To describe and analyse linear, circular and elliptical polarization of light.(K) **CSO 4.2:** To understand the mathematical representation and physical characteristics of each type of polarization.(U) **CSO 4.3:** To explain the behaviour of electromagnetic waves in anisotropic media.(U) **CSO 4.4:** To understand the role of the dielectric tensor and its symmetric nature in anisotropic materials.(U) **CSO 4.5:** To apply Fresnel's formula to calculate reflection and transmission coefficient at the interface between different media.(A) **CSO 4.6:** To apply Fresnel's formula in anisotropic media.(A) **CSO 4.7:** To understand the properties and characteristics of uniaxial and biaxial crystals and ability to analyse the behaviour of light propagation in these crystals.(U) **CSO 4.8:** To describe the phenomena of double refraction and polarization by double refraction in uniaxial crystals. (K) **CSO 4.9:** To cite the concept such as ordinary and extraordinary refractive indices.(K) **CSO 4.10:** To explain plane, circularly and elliptically polarized light.(U) **CSO 4.11:** To explain and familiarize with polarization devices such as Nicol prism.(U) **CSO 4.12:** To understand the principle and application of phase	11	25	Not to be filled-in

		retardation plates.(U) **CSO 4.13:** To calculate and apply the properties of quarter-wave and half-wave plates.(A) **CSO 4.14:** To understand the Babinet compensator and its application in optical systems and solve problem. (U) **CSO 4.15:** To analyse the properties of polarized light. (A) **CSO 4.16:** To apply Fresnel theory in calculating the angle of rotation and specific rotation. (A) **CSO 4.17:** To design and conduct experiment to verify Fresnel's theory of optical rotation. And familiarize with experimental setups, including Laurent's half-shade polarimeter. (A)			
UNIT 5 **Wave Guides**	**Wave Guides:** Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigen value equations. Phase and group velocity of guided waves. Field energy and Power transmission.	**CSO 5.1:** To understand the fundamental principles and components of planar optical waveguides.(U) **CSO 5.2:** To describe the structure and operation of planar waveguide system.(K) **CSO 5.3:** To analyse the behaviour of electromagnetic waves in planar dielectric waveguide.(A) **CSO 5.4:** To apply dielectric properties in the design and analysis of planar waveguide.(A) **CSO 5.5:** To understand the importance of boundary condition in waveguide design(U) **CSO 5.6:** To discuss the phase shift that occur during total internal reflection in waveguides and application of phase shift concept in waveguide analysis and design.(U) **CSO 5.7:** To derive and solve eigenvalue equation for guided modes in planar waveguide.(A) **CSO 5.8:** To understand the concept of phase and group velocity for guided waves in planar waveguides and application of velocity concept in analysing waveguide characteristics.(U) **CSO 5.9:** To calculate and	7	16	Not to be filled-in

		understand the field energy associated with waves and application of field energy concept in waveguide analysis.(A) **CSO 5.10:** To calculate power transmission characteristics in planar waveguides and proficiency in analysing power distribution and losses in waveguide systems.(A)			

SUGGESTED READINGS:

1. D.J. Griffiths, *Introduction to Electrodynamics*, 3rd Ed., Benjamin Cummings, 1998.
2. M.N.O. Sadiku, *Elements of Electromagnetics*, Oxford University Press ,2001.
3. T.L. Chow, *Introduction to Electromagnetic Theory*, Jones & Bartlett Learning, 2006.
4. M.A.W. Miah, *Fundamentals of Electromagnetics*, Tata McGraw Hill ,1982.
5. R.S. Kshetrimayun, *Electromagnetic field Theory*, Cengage Learning, 2012.
6. Willian H. Hayt, *Engineering Electromagnetic*, 8th Edition, McGraw Hill, 2012.
7. G. Lehner, *Electromagnetic Field Theory for Engineers & Physicists*, Springer ,2010.

Semester	VI
Paper Code	PHC 6.3(P)
Paper Title	Electromagnetic Theory
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory objective:

Establishes the basic principle of electrical and electronic circuits**.**

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by suitable method (using a Babinet‘s compensator).
4. To study the polarization of light by reflection and determine the polarizing angle and hence determine the refractive index of the material.
5. To verify the Stefan‘s law of radiation and to determine Stefan‘s constant.
6. To determine the Boltzmann constant using V-I characteristics of PN junction Diode

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House, 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers ,reprinted 1985.
3. I.Prakash& Ramakrishna ,*A Text Book of Practical Physics* , 11th Ed., Kitab Mahal ,2011.
4. G. Lehner, *Electromagnetic Field Theory for Engineers & Physicists*, Springer, 2010.

Semester	VI
Paper Code	PHC 6.4
Paper Title	Statistical Mechanics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper Statistical Mechanics:

CO 1:	To make the students aware of the importance of Classical statistics.
CO 2:	To make the students aware in using Classical theory to explain radiation and the drawbacks involved in Classical theory of radiation.
CO 3:	To create an understanding among the students about the need for quantum theory of radiation.
CO 4:	To introduce students in the importance of Bose Einstein statistics.
CO 5:	To assist the students in the understanding of Fermi- Dirac statistics

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Classical Statistics	Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	**CSO 1.1:** To explain the concept of Macrostate and Microstate. (U) **CSO 1.2:** To describe the elementary concept of ensemble. (K) **CSO 1.3:** To explain phase space (U) **CSO 1.4:** To discuss entropy and thermodynamic probability. (U) **CSO 1.5:** To derive the Maxwell-Boltzmann distribution law. (A) **CSO 1.6:** To derive the partition function. (A) **CSO 1.7:** To examine thermodynamic functions of an ideal gas. (A) **CSO 1.8:** To derive classical entropy expression. (A) **CSO 1.9:** To describe Gibbs Paradox. (K) **CSO 1.10:** To derive Sackur Tetrode equation. (A) **CSO 1.11:** To explain law of equipartition of energy. (U) **CSO 1.12:** To apply law of equipartition energy to specific heat. (A)	13	24	Not to be filled-in

		CSO 1.13: To list the limitations of Law of equipartition energy. (K) **CSO 1.14:** To discuss thermodynamic functions of a two-energy level system. (U) **CSO 1.15:** To explain negative temperature. (U)			
UNIT 2 Classical Theory of Radiation	Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.	**CSO 2.1:** To list the properties of thermal radiation. (K) **CSO 2.2:** To explain Blackbody radiation. (U) **CSO 2.3:** To explain pure temperature dependence. (U) **CSO 2.4:** To describe Kirchoff's law. (K) **CSO 2.5:** To explain Stefan-Boltzmann law. (U) **CSO 2.6:** To derive the thermodynamic proof of Stefan-Boltzmann law. (A) **CSO 2.7:** To understand radiation pressure. (U) **CSO 2.8:** To discuss Wein's displacement law. (U) **CSO 2.9:** To explain Weins's distribution law. (U) **CSO 2.10:** To derive Saha's Ionization formula. (A) **CSO 2.11:** To explain Rayleigh-Jean's law. (U) **CSO 2.12:** To explain Ultraviolet catastrophe. (U)	8	19	Not to be filled-in
UNIT 3 Quantum Theory of Radiation	Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	**CSO 3.1:** To explain the spectral distribution of Black Body radiation. (U) **CSO 3.2:** To explain Plank's Quantum Postulates. (U) **CSO 3.3:** To apply Plank's law in explaining blackbody radiation and study its experimental verification. (A) **CSO 3.4:** To deduce Wein's distribution law from Plank's law. (A) **CSO 3.5:** To deduce Rayleigh-Jeans law from Plank's law. (A) **CSO 3.6:** To deduce Stefan Boltzmann law from Plank's law. (A) **CSO 3.7:** To deduce Wein's displacement law from Plank's law. (A)	10	23	Not to be filled-in

		CSO 3.8: To explain Gauss Seidel method and its derivative. (U)			
UNIT 4 **Bose-Einstein Statistics**	B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	**CSO 4.1:** To derive Boltzmann-Einstein statistics. (A) **CSO 4.2:** To examine thermodynamic functions of a strongly degenerate Bose Gas. (A) **CSO 4.3:** To explain Bose Einstein Condensation. (U) **CSO 4.4:** To list properties of liquid Helium. (K) **CSO 4.5:** To discuss radiation as photon gas. (U) **CSO 4.6:** To explain thermodynamic functions of photon gas. (U) **CSO 4.7:** To examine Bose derivation of Plank's law. (A)	7	17	Not to be filled-in
UNIT 5 Fermi-Dirac Statistics	Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	**CSO 5.1:** To derive Fermi Dirac distribution law. (A) **CSO 5.2:** To examine the thermodynamic functions of a completely and strongly degenerate Fermi Gas. (A) **CSO 5.3:** To deduce Fermi energy. (A) **CSO 5.4:** To explain electron gas in a metal. (U) **CSO 5.5:** To elaborate on relativistic Fermi gas. (A) **CSO 5.6:** To describe white dwarf stars. (K) **CSO 5.7:** To describe Chandrashekhar mass limit. (K)	7	17	Not to be filled-in

SUGGESTED READINGS:

1. R.K. Pathria, Butterworth Heinemann ,*Statistical Mechanics*, 2nd Ed., Oxford University Press ,1996.
2. F. Reif, *Statistical Physics, Berkeley Physics Course*, Tata McGraw-Hill ,2008.
3. S. Lokanathan and R.S. Gambhir, *Statistical and Thermal Physics*, Prentice Hall ,1991.
4. Francis W. Sears and Gerhard L. Salinger,*Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, Narosa ,1986.
5. Carl S. Helrich, *Modern Thermodynamics with Statistical Mechanics*, Springer, 2009,
6. R.H. Swendsen, *An Introduction to Statistical Mechanics & Thermodynamics*, Oxford Univ. Press ,2012.

Semester	VI
Paper Code	PHC 6.4(P)
Paper Title	Statistical Mechanics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

With the exposure in computer programming and computational techniques, the student will be in a position to perform numerical simulations for solving the problems based on Statistical Mechanics.

Use C/C++/Scilab for solving the problems based on Statistical Mechanics like

1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

SUGGESTED READINGS:

1. K.E.Atkinson, *Elementary Numerical Analysis*, 3rd Edn. ,Wiley India Edition ,2007.
2. R.K. Pathria, Butterworth Heinemann, *Statistical Mechanics*, 2nd Ed., 1996, Oxford University Press.
3. Thermodynamics, *Kinetic Theory and Statistical Thermodynamics*, Narosa ,1986,.
4. Francis W. Sears and Gerhard L. Salinger, *Modern Thermodynamics with Statistical Mechanics*, Carl S. Helrich, Springer, 2009.
5. M. Affouf, *Scilab by example*: ISBN: 978-1479203444 , 2012.
6. L.M.Surhone, *Scilab Image Processing*, Beta script Pub., ISBN: 978- 6133459274,2010.

Semester-VII

Semester	VII
Paper Code	PHC 7.1
Paper Title	Astronomy and Astrophysics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Astronomy and Astrophysics**:

CO 1:	To create an awareness among the students on Astronomical Scales and the Basic concepts of positional astronomy
CO 2:	To instill the idea of Astronomical techniques and Physical principles relating to astronomy
CO 3:	To let the students understand the concepts of The sun, The solar family and the Stellar spectra and it classifications
CO 4:	To make the students aware about the galaxy The milky way and its structure
CO 5:	To assist the students in understanding Large scale structure & the expanding universe

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Astronomical Scales and Basic concepts of positional astronomy	**Astronomical Scales:** Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. **Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a	**CSO 1.1:** To define various astronomical scales like distance, mass, time, brightness, radiant flux, luminosity, etc. (K) **CSO 1.2:** To explain on radiant flux and luminosity and derive its relationship (U+K+A) **CSO 1.3:** To discuss on the various astronomical quantities like radii, mass, temperature, etc. (K+U) **CSO 1.4:** To define and explain on the idea of celestial sphere and its relevance in astronomy (K+U) **CSO 1.5:** To explain on the idea of geometry of sphere and Spherical triangle(K+U) **CSO 1.6:** To explain on the coordinate systems (A+U) **CSO 1.7:** To define Diurnal motion of stars (K) **CSO 1.8:** To explain in detail about diurnal motion and its applications (A+U) **CSO 1.9:** To discuss of the conversion of coordinate	14	23	Not to be filled -in

	star.	systems in astronomy (U+A) **CSO 1.10:** To discuss on the measurement of time in astronomy (K+U+A) **CSO 1.11:** To discuss and explain on the determination of distance in astronomy using methods like parallex method, radiant and luminosity etc (U+A) **CSO 1.12:** To explain on measurement of distance using distance modulus method, temperature and radius of stellar objects. (U+A)			
UNIT 2 Astronomical techniques and Physical principles	**Astronomical techniques**: Basic Optical Definitions for Astronomy(Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes(Types of Detectors, detection Limits with Telescopes). **Physical principles:** Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.	**CSO 2.1:** To define the various optical terms in astronomy (K) **CSO 2.2:** To define telescope (K) **CSO 2.3:** To explain on the types of telescopes (U) **CSO 2.4:** To discuss on the various uses and importance of telescope in astronomy (U+A) **CSO 2.5:** To define telescope mounting (K) **CSO 2.6:** To explain on the different types of mounting and its advantages (U+A) **CSO 2.7:** To define detectors (K) **CSO 2.8:** To explain on the advantage of using detectors with telescope (K+U) **CSO 2.9:** To understand the gravitation using Virial theorem, Newton and Einstein development (U+A) **CSO 2.10:** To introduce the idea of Systemsin Thermodynamic Equilibrium. (U)	11	19	Not to be filled -in
UNIT 3 The sun, Stellar spectra and classification Structure	**The sun:** Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helio seismology. **The solar family:** Solar System: Facts and	**CSO 3.1:** To define Sun(K) **CSO 3.2:** To explain on the structure of the sun(U) **CSO 3.3:** To discuss of the atmosphere of the sun (U) **CSO 3.4:** To discuss on the various activity and the magneto-hydrodynamics of the sun (K+U)	11	19	Not to be filled -in

	Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings. **Stellar spectra and classification Structure :**Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram.	**CSO 3.5:** To Discuss on the facts and figures of the solar system (K+U) **CSO 3.6:** To discuss on the origin of the solar system Using various models (U+K) **CSO 3.7:** To explain on solar spectra and classification structure using various methods and parameters **CSO 3.8:** To explain HR-diagram and its importance			
UNIT 4 **The milky way**	**The milky way**: Galaxy Morphology, Hubble's Classification of Galaxies Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way(Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms),Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.	**CSO 4.1:** To define milky way and get acquainted to facts and figures of the galaxy(K) **CSO 4.2:** To discuss the morphology of milky way galaxy in detail(U) **CSO 4.3:** To study the different types of galaxy using Hubble's classification (K+U) **CSO 4.4:** To discuss the structure and properties of milky way galaxy and its rotation. (K+U) **CSO 4.5:** To define and explain on star clusters of the milky way galaxy(U) **CSO 4.6:** To discuss on the property around the galactic nucleus (U)	13	21	Not to be filled -in
UNIT 5 **Large scale structure & expanding universe:**	**Large scale structure &expanding universe:** Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance-Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).	**CSO 5.1:** To introduce on the large scale structures of the universe(K) **CSO 5.2:** To explain on the cosmic distance ladder (U) **CSO 5.3:** To explain on the expanding universe with the help of Hubble's law (K+U) **CSO 5.4:** To study on the clusters of galaxies in the universe and its properties(K+U) **CSO 5.5:** To discuss on the idea of dark matter and dark energy(U)	11	18	Not to be filled -in

SUGGESTED READINGS:

1. M. Zeilik and S.A. Gregory ,*Introductory Astronomy and Astrophysics*, 4th Edition, Saunders College Publishing.
2. H. Karttunen ,*Fundamental of Astronomy* (Fourth Edition), et al. Springer.

3. K.S. Krishnasamy, '*AstroPhysics a modern perspective*,' Reprint, New Age International (p) Ltd, New Delhi,2002.
4. Baidyanath Basu, '*An introduction to Astro physics*', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.

Semester	VII
Paper Code	PHC 7.2
Paper Title	Material Science and Nano Technology
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Material Science and Nano Technology**:

CO 1:	To Introduce the concept and structure of materials and their properties.
CO 2:	To instill the idea of film deposition techniques among the students.
CO 3:	To let the students understand the concept of applications of coatings as finishes for various substrates.
CO 4:	To Introduce to the concept of Nanomaterials and its properties.
CO 5:	To assist the students in understanding Carbon based Nanomaterials.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction and structure of materials and study of properties of materials	Structure of atoms-Quantum states-Atomic bonding in solids-binding energy-interatomic spacing - variation in bonding characteristics - Single crystals – polycrystalline- Non crystalline solids-Imperfection in solids–Schmidt's law -Surface imperfection-grain size distribution	**CSO 1.1:** To discuss about the basic structure of atoms. (U) **CSO 1.2:** To illustrate on Atomic quantum state, atomic bonding.(U+A) **CSO 1.3:** To define and discuss on binding energy and interatomic spacing. (K+U+A) **CSO 1.4:** To define and characterise different types of crystals .(K+U+A) **CSO 1.5:** To discuss on imperfection in solids .(U+A) **CSO 1.6:** To discuss on grain size distribution using Schmidt's law.	14	23	Not to be fille d-in
UNIT 2 Film deposition techniques	Physical method of film deposition, Sputter deposition of thin films and coatings by RF, MF, DC, Magnetron, Pulsed laser, Ion beam, Ion implantation;	**CSO 2.1:** To define and discuss on deposition. (K+U) **CSO 2.2:** To illustrate on the physical methods of film deposition by using the methods mentioned.	14	23	Not to be fille d-in

	Chemical method of film deposition-electroplating, electro less plating, electro polishing, electroforming, chemical vapour deposition(CVD) and plasma enhanced CVD; Other techniques-Langmuir Blodgett, Spin coating Inter diffusion, reactions and transformations in thin films.	(U+A) **CSO 2.3:** To define and discuss chemical deposition. (K+U) **CSO 2.4:** To explain on the chemical deposition method by using the techniques mentioned .(U+A) **CSO 2.5:** To discuss about some other techniques like Langmuir Blodgett, Spin coating ,etc. (A) **CSO 2.6:** To discuss on the various techniques that brought transformation in thin films .(U+A) **CSO 2.7:** To compare and contrast the various methods. (A)			
UNIT 3 Applications of coatings as finishes for various substrates	UV resistant, Atomic oxygen resistant and antistatic coating; Optical coatings for thermal control application-thermal barrier and thermal protective coating; Self-healing coating, Testing and evaluation of coatings	**CSO 3.1**: To introduce to various application of coatings. (U) **CSO 3.2:** To illustrate on UV resistant coatings and its advantages. (A) **CSO 3.3:** To explain on Atomic oxygen resistant coating and its advantages and disadvantages .(U+A) **CSO 3.4:** To illustrate on antistatic coating and it merits and demerits. (U+A) **CSO 3.5:** To discuss on thermal barrier and thermal protective coating and its merits and demerits .(U+A) **CSO 3.6:** To explain Self-healing coating a its merits and demerits. (U+A) **CSO 3.7:** To discuss on the various and evaluate its efficiency. (A)	12	17	Not to be filled-in
UNIT 4 Introduction to Nanomaterials and properties	Brief history and overview of nano materials; Synthesis techniques: Top down and Bottom up approaches (High energy ball milling, Sol-gel process, Chemical bath deposition, Plasma Arc discharge, Chemical vapour deposition,	**CSO 4.1:** To define nanomaterials. (K) **CSO 4.2:** To discuss about nanomaterials and its properties.(U) **CSO 4.3:** To discuss on the synthesis techniques of nanomaterials using the mentioned approaches. (A) **CSO 4.4:** To discuss on the characterization tools of nanomaterials. (A)	12	20	Not to be filled-in

	Sputtering, Pulsed Laser deposition, Molecular beam epitaxy). Characterization tools of Nanomaterials.	**CSO 4.5:** To compare and contrast the various techniques and evaluate its efficiency. (U+A)			
UNIT 5 Carbon based Nano materials	Nature of carbon bond, Carbon structures, Small carbon clusters; Introduction to Synthesis and Applications of Fullerenes, Graphene and Carbon nanotubes.	**CSO 5.1:** To define carbon based nanomaterials. (K) **CSO 5.2:** To discuss on how carbon based nano material is different from normal nanomaterial. (U) **CSO 5.3:** To discuss on the nature of carbon bond. (U+A) **CSO 5.4:** To study the structure of carbon and its importance. (U+A) **CSO 5.5:** To discuss on clusters of carbon. (U) **CSO 5.6:** To discuss on this synthesis of fullerene, graphene and carbon nanotube .(K+U+A) **CSO 5.7:** To explain about the application of fullerene, graphene and carbon nanotubes. (A)	8	17	Not to be fille d-in

SUGGESTED READINGS:

1. W.D.Callister,*Materials Science and Engineering*:An Introduction ,John Wiley & Sons,2007.
2. C.Kittel,*Introduction to Solid State Physics*,Wiley Eastern Ltd,2005.
3. V.Raghavan,*Materials Science and Engineering*:A First Course,Prentice Hall,2006.
4. K.L.Chopra,*Thin Film Phenomena*,Mc Graw Hill,1979.
5. M.H.Francombe,S.M.Rossnagel,A.Ulman,*Frontiers of Thin Film Technology*,Vol.28,Academic press,2001.
6. R.F.Bunshah,*Deposition Technologies for Films and Coatings*,Noyes Publications,NewJersey,1982.
7. F.A.Lowenheim,*Electro plating*,Mc Graw Hill,NewYork,1978.

Semester	VII
Paper Code	RM
Paper Title	Research Methodology
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Research Methodology**:

CO 1:	To make the students aware of the process of scientific research.
CO 2:	To aid the students in the understanding of the ethical aspects of the research.
CO 3:	To guide the students on how to formulate research problems.
CO 4:	To inculcate and create interest among students in the importance of data analysis.
CO 5:	To assist the students in developing communication technique in the field of research.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **The process of scientific research**	The student will • Refer to journals, conferences, books, magazines and any relevant papers related to their area of research. • Understand and identify the bias, theoretical position and evidence produced, compare ideas and concepts. • write a summary and answer to questions related with the epistemology of science and the scientific methods in Physics. It will be assessed on the ability to synthesize, the accuracy in the answers and the presentation and discussion in class.	**CSO 1.1:** To explain to students on the importance of referring to journals, conferences, books, magazines and relevant papers related to their area of research. (U) **CSO 1.2:** To breakdown the reading materials and thus help the students identify the bias, theoretical position and evidences provided. As a result, they realise how to compare ideas and concepts related to their research. (A) **CSO 1.3:** To outline the important points in the reading materials and help the student elaborate the answer related to the questions. (K)	10	17	Not to be filled-in
UNIT 2 **Ethical aspects of the research**	The student will • Analyse a scientific fraud and discuss its key points. • Maintain personal and	**CSO 2.1:** To clarify to students about the pitfall in plagiarising someone else's	10	17	Not to be filled-in

	internal code of conduct. It will be assessed on the ability to maintain the ethics in a research work.	work and how it will affect the credibility of our research. To make the students aware of scientific fraud and its key points. (U) **CSO 2.2:** To aware the students in maintaining personal and internal code of conduct. (A)			
UNIT 3 **Formulation of research problems**	The student will have to • Define and formulate the research problem - Selecting the problem, necessity of defining the problem • Importance of literature review in defining a problem- Critical literature review, Identifying gap areas from literature review • Develop a working hypothesis It will be assessed on the basis of how accurately the problem and research gap has been identified.	**CSO 3.1:** To assess the students in defining and formulating the research problems- selecting the problem. (A) **CSO 3.2:** To explain to students about the importance of literature review in defining a problem- critical literature review, identifying gap areas from literature review. (U) **CSO 3.3:** To develop a working hypothesis. (A)	12	20	Not to be filled-in
UNIT 4 **Data Analysis**	The student will have to • Execute the research • Observe and collect data • Specify methods used to collect data • Extrapolate/scale data for validation • Editing and coding of data, tabulation, graphic presentation of data, cross tabulation, testing of hypothesis	**CSO 4.1:** To support the students in executing the research. (A) **CSO 4.2:** To demonstrate to students to observe and collect data. (A) **CSO 4.3:** To enumerate the methods used to collect data. (K)	14	23	Not to be filled-in

	It will be assessed on the relevance and suitability of the calls made to tackle the problems identified	**CSO 4.4:** To verify the extrapolated/scale data. (A) **CSO 4.5:** To explain editing and coding of data, tabulation, graphic presentation of data, cross tabulation, testing of hypothesis. (U)			
UNIT 5 Communication techniques	The students will have to • Produce a research paper in the format appropriate for a research work. • Typed using latex software. It will be assessed on • The design and preparation of the paper according to the requirements of the research work. • The clarity in the exposition of ideas and the correctness in the use of the English language. • The abstract and the conclusions. • The use of adequate bibliographic references. • The use of relevant figures and / or tables. This work will have to be defended in public with the help of a PowerPoint type presentation. It will be assessed on • The order and clarity of the presentation.	**CSO 5.1:** To arrange a research paper in the format appropriate for a research work. (A) **CSO 5.2:** To introduce to students' latex software to type the research paper. (K)	14	23	Not to be filled-in

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Semester-VIII

Semester	VIII
Paper Code	PHC 8.1
Paper Title	Photonics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Photonics**:

CO 1:	To make the students aware of the basic principles of lasers.
CO 2:	To aid the students in the understanding of laser system and help them to understand its applications.
CO 3:	To create an understanding among the students, the non-linear optics basic principles.
CO 4:	To inculcate and create interest among students in the understanding of fibre optics and its applications.
CO 5:	To assist the students in the understanding of Fibre Optic Components and Sensors.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Basic principles of lasers.	Spontaneous and stimulated emission – Coherence - Population inversion- Einstein coefficients – Pumping schemes – Threshold condition for laser oscillation – Losses and Q-factor –Principles and working mechanisms of Ruby, Nd:YAG, Ar ion, CO2 and semiconducting lasers – Applications	**CSO 1.1:** To define and explain spontaneous and stimulated emission. (K) **CSO 1.2:** To explain coherence of laser light.(U) **CSO 1.3:** To explain the mechanism behind population inversion. (U) **CSO 1.5:** To explore Einstein coefficient and explain its practical applications. (A) **CSO 1.6:** To discuss pumping scheme. (U) **CSO 1.7:** To understand the threshold condition for laser oscillation. (U) **CSO 1.8:** To examine the concept of losses and Q-factor of lasers. (A) **CSO 1.9:** To explain the principles and determine the working mechanisms of Ruby lasers, Nd:YAG,	9	20	Not to be filled-in

		Ar ion, CO2 and semiconducting lasers. (U) and (A)			
UNIT 2 LASER systems and Applications	General description, Laser structure, Single mode laser theory, Excitation mechanism andworking of: CO2, Nitrogen, Argon ion, Excimer, X-ray, Free-electron, Dye, Nd:YAG,Alexanderite and Ti:sapphire lasers, Diode pumped solid state laser, Optical parametricoscillator (OPO) lasers. Optical amplifiers-Semiconductor optical amplifiers, Erbium dopedwaveguide optical amplifiers, Raman amplifiers, Fiber Lasers. Laser applications-Lasers inIsotope separation, Laser interferometry and speckle metrology, Velocity measurements, Laser induced fusion in reactor, Laser cooling and trapping.	**CSO 2.1:** To outline a general description of lasers systems. (K) **CSO 2.2:** To explain Laser structure. (U) **CSO 2.3:** To explain single mode laser theory. (U) **CSO 2.4:** To explain Excitation mechanism and working of different types of lasers: CO2, Nitrogen, Argon ion, Excimer, X-ray, Free-electron, Dye, Nd:YAG, Alexanderite and Ti:sapphire lasers, Diode pumped solid state laser, Optical parametric oscillator (OPO) lasers **CSO 2.5:** To define optical amplifiers. (K) **CSO 2.6:** To explain different types of optical amplifier: Semiconductor optical amplifiers, Erbium doped wave guide optical amplifiers, Raman amplifiers. (U) and (A) **CSO 2.7:** To define and explain fiber laser. (K) **CSO 2.8:** To examine the uses of lasers: Lasers in Isotope separation, Laser interferometry and speckle metrology, Velocity measurements, Laser induced fusion in reactor, Laser cooling and trapping. (A) **CSO 2.9:** To describe different types of lasers: CO2, Nitrogen, Argon ion, Excimer, X-ray, Free-electron, Dye, Nd:YAG, Alexanderite and Ti:sapphire lasers, Diode pumped solid state laser, Optical parametric oscillator (OPO) lasers. (K)	9	20	Not to be filled-in
UNIT 3 Non-linear	Origin of optical nonlinearity -	**CSO 3.1:** To define and explain the origin of	9	20	Not to be filled-in

Optics Basic Principles	Harmonic generation – Second harmonic generation – Phase matching condition – Third harmonic generation – Optical mixing – Parametric generation of light – Parametric light oscillator – Frequency upconversion – Self focusing of light – Phase conjugate optics-Guided wave optics - Nonlinear optical materials.	optical nonlinearity. (K) **CSO 3.2:** To define harmonic generation. (K) **CSO 3.3:** To explain second harmonic generation. (U) **CSO 3.4:** To explain phase matching condition.(U) **CSO 3.5:** To explain third harmonic generation.(U) **CSO 3.6:** To explain the principle of optical mixing and analyse its application. (A) **CSO 3.7:** To explain the principle of parametric generation of light and its application. (A) and (U) **CSO 3.8:** To explain parametric light oscillator. (U) **CSO 3.9:** To discuss the principle of frequency up conversion. (U) **CSO 3.10:** To understand the principle of self-focusing of light. (K) **CSO 3.11:** To explore Phase conjugate optics-Guided wave optics. (A) **CSO 12:** To describe and explain non linear optical materials. (K)			
UNIT 4 **Fiber Optics :**	Total internal reflection - Optical fiber modes and configuration – Single mode fibers – Graded index fiber structure – Fiber materials and fabrication – Mechanical properties of fibers – Fiber optic cables –Attenuation – Signal distortion on optical wave guides-Erbium doped fiber amplifiers – Solitons in optical fibers - Block diagram of fiber optic communication system - Applications of optical fibers in	**CSO 4.1:** To define and explain total internal reflection. (K) **CSO 4.2:** To define and explain optical fiber modes and its configuration. (K) and (U) **CSO 4.3:** To describe single mode fiber. (U) **CSO 4.4:** To explain graded index fiber structure. (U) **CSO 4.5:** To state and explain different fiber materials and fabrication process. (K) **CSO 4.6:** To discuss the mechanical properties of fibers. (U) **CSO 4.7:** To define and explain fiber optic cables.	9	20	Not to be filled-in

	communication and medicine.	(U) **CSO 4.8:** To analyse attenuation on fibre optics. (A) **CSO 4.9:** To analyse signal distortion on optical wave guides. (A) **CSO 4.10:** To describe the Erbium doped fiber amplifiers. (K) **CSO 4.11:** To discuss the concept of solitons in optical fiber. (U) **CSO 4.12:** To demonstrate Block diagram of fiber optic communication system. (A) **CSO 4.13:** To explore the applications of optical fibers in communication and medicine.(A)			
UNIT 5 **Fibre Optic Components and Sensors :**	Connector principles, Fibre end preparation, Splices, Connectors, Source coupling, distribution networks, Directional couplers, Star couplers, Switches, Fiber optical isolator,Wavelength division multiplexing, Time division multiplexing, Fiber Bragg gratings.Advantage of fiber optic sensors, Intensity modulated sensors,Mach-Zehnder interferometer sensors, Current sensors, Chemical sensors –Fiber optic rotation sensors. Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Bio-imaging, Bio sensing.	**CSO 5.1:** To state and explain the connector principles. (K) **CSO 5.2:** To examine fibre end preparation. (A) **CSO 5.3:** To explain the concept of splices. (U) **CSO 5.4:** To describe the concept of connectors. (K) **CSO 5.5:** To define and explain source coupling. (K) **CSO 5.6:** To discuss the distribution networks. (U) **CSO 5.7:** To define and explain directional couplers. (K) **CSO 5.8:** To describe star couplers. (K) **CSO 5.9:** To explain the concept of switches. (U) **CSO 5.10:** To explain fibre optical isolator. (U) **CSO 5.11:** To discuss the concept of wavelength divison multiplexing and time division multiplexing. (U) **CSO 5.12:** To describe Fiber Bragg gratings. (K) **CSO 5.13:** To identify the advantages of fiber optic sensors, intensity	9	20	Not to be filled-in

		modulated sensors, Mach-Zehnder interferometer sensors, Current sensors, Chemical sensors –Fiber optic rotation sensors. (A) **CSO 5.14:** To define optical biosensors. (K) **CSO 5.15:** To examine the concept of fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, bio- imaging, bio sensing. (A)			

SUGGESTED READINGS:

1. D.J. Griffiths, *Introduction to Electrodynamics*, 4 th Edition, Prentice-Hall of India, ND, 2013.
2. G.R. Fowels, *Modern Optics* , 1989.
3. M.J. Beesly, *Laser and their Applications*, Taylor and Francis, 1976.
4. B.B. Laud, *Lasers and Non-Linear Optics*, 3rd Edition, New Age International Publishers Ltd, 2011.
5. *Optics*, E. Hecht, Addison Wiley, 1974. 9. *Optical Fiber Communications*, Gerel Keiser, McGraw Hill Book, 2000.
6. J. Wilson and J.F.B. Hawkes, *Lasers, principles and applications*prentice, Hall of India, New Delhi, 1996.
7. Joseph C. Palais, *Fibre Optic Communication*, Pearson Education Asia, India, 2001.
8. A.Ghatak And K.Thyagarajan, *Introduction To Fibre Optics*, Cambridge UniversityPress,New Delhi, 1999.

Semester	VIII
Paper Code	PHC 8.1(P)
Paper Title	Photonics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The objective of this lab is to become familiar with the fundamental properties of light and explore, illustrate the applications of photonic principles..

Course Content:

1. Verification of Gaussian nature of the given laser beam
2. Evaluation of divergence angle of the laser beam
3. Determined the beam divergence and spot size of a given laser
4. Determination of wavelength of a He-Ne laser beam using Mach-Zender Interferometer
5. Measurement of refractive index of the air using Mach-Zender Interferometer
6. Measurement of refractive index of the transparent materials using Mach-Zender Interferometer
7. Study the characteristics of the diode current versus optical output powers
8. Study the characteristics of the temperature dependence of the threshold current for laser emission
9. Construct the Diffraction Grating by using Holography technique
10. Measurement of propagation loss using optical power meter.
11. Study the Electro-Optic effect in LiNbO3 Crystal and calculate the half-wave voltage

Semester	VIII
Paper Code	PHC 8.2
Paper Title	Biophysics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Bio Physics**:

CO 1:	To make the students understand the building blocks and structure of living state as well as living state interactions.
CO 2:	To guide the students in the understanding of heat transfer mechanism in biomaterials and thermodynamics involved in living state.
CO 3:	To assist the students in learning about open systems. Chemical thermodynamics and diffusion and transport mechanisms.
CO 4:	To create an interest among students in the understanding Fluids.
CO 5:	To aid the students in the understanding of Bioenergetics and Molecular motors.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Building Blocks & Structure of Living State and Living State Interactions**	**Building Blocks & Structure of Living State:** Atoms and ions, molecules essential for life, what is life. **Living State Interactions:** Forces and molecular bonds, electric & thermal interactions, electric dipoles, Casimir interactions, domains of physics in biology.	**CSO 1.1:** To define atoms and ions. (K) **CSO 1.2:** To describe molecules essential for life. (K) **CSO 1.3:** To discuss what is life. (U) **CSO 1.4:** To describe forces and molecular bonds. (K) **CSO 1.5:** To explain electric and thermal interactions. (U) **CSO 1.6:** To evaluate electric dipoles. (A) **CSO 1.7:** To discuss Casimir interactions. (U) **CSO 1.8:** To discuss the domains of physics in biology. (U)	15	23	Not to be filled-in
UNIT 2 **Heat Transfer in biomaterials and Living State Thermodynamics**	**Heat Transfer in biomaterials:** Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **Living State Thermodynamics:** Thermodynamic equilibrium, first law of thermodynamics and conservation of	**CSO 2.1:** To explain heat transfer mechanism. (U) **CSO 2.2:** To derive the heat equation. (A) **CSO 2.3:** To discuss Joule heating of tissue. (U) **CSO 2.4:** To describe thermodynamic equilibrium. (K) **CSO 2.5:** To state and	17	25	Not to be filled-in

	energy. Entropy and second law of thermodynamics, Physics of many particle systems, two state systems, continuous energy distribution, Casimir contribution of free energy	define the first law of thermodynamics. (K) **CSO 2.6:** To discuss the conservation of energy. (U) **CSO 2.7:** To explain entropy and the second law of thermodynamics. (U) **CSO 2.8:** To determine the physics of many particles system. (A) **CSO 2.9:** To discuss two state systems. (U) **CSO 2.10:** To explain continuous energy distribution. (U) **CSO 2.11:** To examine Casimir contribution of free energy. (A)			
UNIT 3 **Open systems, chemical thermodynamics, Diffusion and transport**	**Open systems and chemical thermodynamics:** Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis& synthesis, Entropy of mixing, The grand canonical ensemble, Haemoglobin. **Diffusion and transport:** Maxwell-Boltzmann statistics, Fick's law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation	**CSO 3.1:** To define enthalpy. (K) **CSO 3.2:** To define Gibbs free energy. (K) **CSO 3.3:** To define chemical potential. (K) **CSO 3.4:** To describe activation energy and rate constants. (K) **CSO 3.5:** To explain enzymatic reactions. (U) **CSO 3.6:** To explain ATP hydrolysis and synthesis. (U) **CSO 3.7:** To discuss entropy of mixing. (U) **CSO 3.8:** To describe the grand canonical ensemble. (K) **CSO 3.9:** To define and describe haemoglobin. (K) **CSO 3.10:** To deduce the Maxwell Boltzmann statistics. (A) **CSO 3.11:** To explain Fick's law of diffusion. (U) **CSO 12:** To discuss sedimentation of cell cultures. (U) **CSO 3.13:** To examine diffusion in a centrifuge. (A) **CSO 3.14:** To examine	15	23	Not to be filled-in

		diffusion in an electric field. (A) **CSO 3.15:** To examine diffusion in membranes. (A) **CSO 3.16:** To derive the Navier stokes equation. (A)			
UNIT 4 **Fluids**	Laminar and turbulent fluid flow, Bernoulli's equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action.	**CSO 4.1:** To define and describe laminar and turbulent fluid flow. (K) **CSO 4.2:** To derive Bernoulli's equation. (A) **CSO 4.3:** To derive equation of continuity. (A) **CSO 4.4:** To explain Venture effects (U) **CSO 4.5:** To discuss fluid dynamics of circulatory systems. (U) **CSO 4.6:** To explain capillary action. (U)	8	14	Not to be filled-in
UNIT 5 **Bioenergetics and Molecular motors**	Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules	**CSO 5.1:** To describe Kinesins. (K) **CSO 5.2:** To describe Dyneins. (K) **CSO 5.3:** To describe microtubule dynamics. (K) **CSO 5.4:** To explain Brownian motion. (U) **CSO 5.5:** To discuss ATP synthesis in Mitochondria. (U) **CSO 5.6:** To discuss photosynthesis in Chloroplasts. (U) **CSO 5.7:** To explore light absorption in biomolecules. (A)	8	15	Not to be filled-in

SUGGESTED READINGS:

1. J. Claycomb,*Introductory Biophysics*, JQP Tran, Jones & Bartelett Publishers.
2. Hughe S W, *Aspects of Biophysics*, John Willy and Sons.
3. P Narayanan ,*Essentials of Biophysics* , New Age International.

Semester	VIII
Paper Code	PHC 8.3
Paper Title	Atmospheric Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Atmospheric Physics**:

CO 1:	To make the students understand the elements of earth's atmosphere that can be observed, measured, and recorded to make predictions and determine simple weather patterns.
CO 2:	To aid the students in the understanding of earth's circulation.
CO 3:	To make the students understand different kind of atmospheric waves and the propagation of atmospheric waves.
CO 4:	To understand the working principle atmospheric radar and lidar.
CO 5:	To assist the students in understanding the importance of aerosols and disadvantages of aerosols.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 General features of Earth's atmosphere	Thermal structure of the Earth's Atmosphere, Ionosphere, composition of atmosphere, Hydrostatic equation, Atmospheric thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmosphere boundary layer, sea breeze and land breeze. Instrument for meteorological observations, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms.	**CSO 1.1:** To define Earth's atmosphere. (K) **CSO 1.2:** To discuss the thermal structure of Earth's atmosphere. (U) **CSO 1.3:** To define ionosphere. (K) **CSO 1.4:** To explain the composition of Earth's atmosphere. (U) **CSO 1.5:** To derive hydrostatic equation. (A) **CSO 1.6:** To explain atmospheric thermodynamics. (U) **CSO 1.7:** To describe green house effect and effective temperature of earth. (K) **CSO 1.8:** To describe local winds, monsoon, fogs, clouds, precipitation, sea breeze and land breeze (K) **CSO 1.9:** To discuss the different instruments for meteorological observation. (U) **CSO 1.10:** To discuss the different meteorological processes. (U)	9	20	Not to be filled-in

		CSO 1.11: To demonstrate cyclones, anti cyclones and thunderstorm. (A)			
UNIT 2 Atmospheric dynamics	Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, Applications of the basic equations, Circulations and velocity, Atmospheric oscillations, Mesoscale circulations, the general circulations, Tropical dynamics.	**CSO 2.1:** To describe atmospheric dynamics. (K) **CSO 2.2:** To discuss the fundamental forces of atmosphere. (U) **CSO 2.3:** To state conservation laws of nature. (K) **CSO 2.4:** To derive the vectorial form of momentum equation in term of rotating coordinate system. (A) **CSO 2.5:** To discuss the circulation of earth. (U) **CSO 2.6:** To describe the velocity of earth's rotation. (K) **CSO 2.7:** To demonstrate the earth circulation in term of atmospheric circulation, mesoscale oscillation and tropical dynamics. (A) **CSO 2.8:** To examine the general circulation of the earth. (A)	9	20	Not to be filled-in
UNIT 3 Atmospheric waves	Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.	**CSO 3.1:** To describe atmospheric waves. (K) **CSO 3.2:** To define acoustic waves, lamb wave, buoyancy wave and rossby wave (K) **CSO 3.3:** To describe wave dispersion. (K) **CSO 3.4:** To discuss the propagation of surface water waves, acoustic waves, buoyancy waves, lamb waves. (U) **CSO 3.5:** To construct the propagation of atmospheric gravitational waves in a non homogeneous medium. (A) **CSO 3.6:** To examine the propagation of rossby wave in a three dimensional coordinate.	9	20	Not to be filled-in

		(A) **CSO 3.7:** To discuss wave absorption. (U)			
UNIT 4 **Atmospheric Radar and Lidar**	Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon.	**CSO 4.1:** To define atmospheric radar. (K) **CSO 4.2:** To define atmospheric lidar. (K) **CSO 4.3:** To differentiate between atmospheric radar and atmospheric lidar. (U) **CSO 4.4:** To derive radar equation. (A) **CSO 4.5:** To discuss the working of Radar. (U) **CSO 4.6:** To demonstrate the signal processing and detection in a radar. (A) **CSO 4.7:** To identify various kind of atmospheric radar. (K) **CSO 4.8:** To apply application of radar in different atmospheric phenomena. (A) **CSO 4.9:** To discuss atmospheric lidar and its different applications. (U) **CSO 4.10:** Todemosstrate the use of lidar in studying atmospheric phenomenas. (A)	9	20	Not to be filled-in
UNIT 5 **Atmospheric Aerosols**	Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques of aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert Law.	**CSO 5.1:** To define atmospheric aerosols. (K) **CSO 5.2:** To define solar radiation. (K) **CSO 5.3:** To discuss the spectral distribution of the solar radiation. (U) **CSO 5.4:** To distinguish the classification of aerosols. (A) **CSO 5.5:** To discuss the properties of aerosols. (U) **CSO 5.6:** To demonstrate the production and removal of aerosols in atmosphere. (A) **CSO 5.7:** To compare the size distribution of aerosols. (A) **CSO 5.8:** To identify the concentration in an aerosols. (K) **CSO 5.9:** To explain the	9	20	Not to be filled-in

		radiative and health of aerosols. (U) **CSO 5.10:** To demonstrate the observational techniques of aerosols. (A) **CSO 5.11:** To examine the absorption of solar radiation and the scattering of solar radiation. (A) **CSO 5.12:** To describe Rayleigh scattering. (K) **CSO 5.13:** To explain mie scattering. (U) **CSO 5.14:** To differentiate between Rayleigh and mei scattering. (U) **CSO 5.15:** To state Bouguert-Lambert law. (K) **CSO 5.16:** To derive Bouguert-Lambert theorem. (A)			

SUGGESTED READINGS:

1. Murry L Salby, *Fundamentals of Atmospheric Physics*, Academic Press, Vol 61, 1996.
2. John T. Houghton, *The Physics of Atmosphere*, Cambridge University press, 3 rdedn. 2002.
3. James R Holton, *An Introduction to dynamic meterology*, Academic press, 2004.
4. S Fukao and K Hamazu, *Radar for meteorological and atmospheric observations*, Springer Japan, 2014.

.INTERDISCIPLINARY MINOR (IDM)

Semester-I

Semester	I
Paper Code	PHM 1
Paper Title	Mechanics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **mechanics**:

CO 1:	To make the students to understand the concept of vector algebra, scalar and vector product and solve the problem relating it with different parameters.
CO 2:	To understand the essential principles in classical mechanics providing a foundation for

	understanding the simple physical system of motion, force and energy from Newton's law of motion.
CO 3:	To create a key concept relating to gravitational physics, celestial mechanics and application of these principles in satellite technology and navigation systems.
CO 4:	To create comprehensive understanding of simple harmonic motion including its mathematical description, energy consideration and behaviour in damped systems
CO 5:	To understand mechanical properties of material under tension, compression and torsion and experimental application.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Vectors	Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients	**CSO 1.1:** To understand the concept of vector algebra and solve the problem relating to it.(U) **CSO 1.2:** To derive the scalar and vector product.(U) **CSO 1.3:** To apply scalar and vector product in solving numerical. (A) **CSO 1.4:** To derive the vector with respect to parameter.(U) **CSO 1.5:**To explain ordinary differential equations.(U) **CSO 1.6:** To analyse 1st and 2nd order homogeneous equation from ordinary differential equations.(A) **CSO 1.7:** To apply differential equation with constant coefficient from homogenous equation.(A)	9	20	Not to be fille d-in
UNIT 2 Laws of Motion	Frames of reference. Newton's Laws of motion. Centre of Mass. Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.	**CSO 2.1:** To understand the concept of frame of reference.(U) **CSO 2.2:** To explain Newton's law of motion governing the motion of objects.(U) **CSO 2.3:** To understand the concept of the point for centre of mass and calculate the purpose of involving the motion. (U) **CSO 2.4:** To understand the conservation of energy.(U) **CSO 2.5:** To explain work and energy and relation between work, energy and force including kinetic energy.(U) **CSO 2.6:**To understand the rotational motion in terms of angular displacement , angular velocity and angular momentum.(U) **CSO 2.7:** To understand the total angular momentum of a system remain constant if no external torques act on it.(U)	9	20	Not to be fille d-in

UNIT 3 Gravitation	Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).	**CSO 3.1:**To state and understand the Newton law of gravitation.(K) **CSO 3.2:** To explain the motion of a particle under the influence of a central force field. (U) **CSO 3.3:**To discuss the concept including motion in a plane, angular momentum is conserved, areal velocities constant.(U) **CSO 3.4:**To state Kepler's law.(K) **CSO 3.5:**To understand the principles and work involve behind the Geosynchronous orbits.(U) **CSO 3.6:**To understand the basic idea of global positioning system (GPS).(U) **CSO 3.7:**To understand the concept of weightlessness in free-fall motion and explaining the experience of weightlessness in certain scenario.(U)	9	20	Not to be fille d-in
UNIT 4 **Oscillation**	Simple harmonic motion, differential equation of SHM and its solutions. Kinetic and potential Energy, total energy and their time averages. Damped oscillations	**CSO 4.1:**To understand the characteristics and behaviour of simple harmonic motion.(U) **CSO 4.2:**To understand the time period and frequency of SHM which are related inversely.(U) **CSO 4.3:**To understand the differential equation that governs SHM and method for solving it.(U) **CSO 4.4:**To explain the energy aspects of SHM including kinetic energy, potential energy and total energy also time averages.(u) **CSO 4.5:** To calculate time average of kinetic and potential energy over one cycle of oscillation. (A) **CSO 4.6:**To understand the role of damping coefficient in determining the rate of decay oscillation.(U) **CSO 4.7:**To explain different damping regimes and their effect on the behaviour of oscillatory system. (U)	9	20	Not to be fille d-in
UNIT 5 Elasticity	Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic	**CSO 5.1:**To understand the fundamental principle that the force needed to extend or compress a spring by some distance is directly proportional to that distance.(U) **CSO 5.2:**To explain Hooke's law and understand the fundamental principle.(U) **CSO 5.3:**To understand the	9	20	Not to be fille d-in

	constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder, Torsional pendulum**.**	graphical representation showing the relation between stress and strain for a material.(U) **CSO 5.4:**To understand different measures of a materials resistance to deformation under stress about Young modulus, shear modulus and bulk modulus.(U) **CSO 5.5:**To explain the relation between elastic constant.(U) **CSO 5.6:**To state and derive the Poisson's ratio and express in terms of elastic constant.(K) **CSO 5.7:**To understand the expression for the work done in stretching and twisting a wire.(U) **CSO 5.8:**To understand the behaviour of a pendulum under torsional oscillation.(U)			

SUGGESTED READINGS:

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

Semester	I
Paper Code	PHM 1(P)
Paper Title	Mechanics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Students would perform basic experiments related to mechanics and also get familiar with various measuring instruments, would learn the importance of accuracy of measurements.

1. To determine the Moment of Inertia of a regular body by Torsional pendulum.
2. To determine the Young's Modulus of a Wire .
3. To determine the Modulus of Rigidity of a Wire .
4. To determine g by Compound Pendulum.
5. To determine g by Kater's Pendulum.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g
8. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
9. Measurements of length (or diameter) using Vernier Calliper, screw gauge and travelling microscope.

SUGGESTED READINGS:

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

Semester-II

Semester	II
Paper Code	PHM 2
Paper Title	Electricity and Magnetism
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Electricity and Magnetism**:

CO 1:	To let the students understand the concept of Vector Analysis:
CO 2:	To instill the idea of Electrostatics
CO 3:	To create an awareness among the students about Magnetism/ Magnetostatics.
CO 4:	To inculcate and create interest among students in Magnetic properties of materials and Electromagnetic Induction
CO 5:	To assist the students in understanding Maxwell`s equations and wave propagation

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Vector Analysis**	Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss divergence theorem and Stoke's theorem of vectors	**CSO 1.1:**To define scalar and vector product (K) **CSO 1.2:**To discuss about scalar and vector product with examples and problems (U+A) **CSO 1.3:**To define and discuss on del operator and its properties (K+U) **CSO 1.4:**To define and discuss on gradient, divergence and curl and their significance. (K+U) **CSO 1.5:**To work out problems based on gradient, divergence and curl (A) **CSO 1.6:**To discuss on vector integration and its types (U)	9	20	Not to be filled-in

		CSO 1.7: To define line, surface, and volume integrals and work out problems based on each integrals (K+U+A) **CSO 1.8:**To define and discuss on Gauss's divergence theorem and Stokes theorem. (K+U) **CSO 1.9:**To work out problems based on the above mentioned theorems (A)			
UNIT 2 **Electrostatics**	Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole.	**CSO 2.1:**To define electrostatics (K) **CSO 2.2:**To define and discuss field and flux in electrostatics (K+U) **CSO 2.3:** To define and derive Gauss's theorem of electrostatics and work out problems based on it. (K+U+A) **CSO 2.4:**To discuss on the application of Gauss's theorem for all the positions mentioned (A) **CSO 2.5:** To define electric potential and calculate potential for point charge and dipole. (K+U+A)	9	20	Not to be filled-in
UNIT 3 **Capacitance and Magnetism: Magnetostatics**	Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. **Magnetism: Magnetostatics**: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.	**CSO 3.1:** To define capacitor and capacitance (K) **CSO 3.2:**To derive capacitance of an isolated conductor, parallel plate, spherical and cylindrical condenser (A) **CSO 3.3:**To work out problems on the above derived capacitances (A) **CSO 3.4:** To calculate energy perm unit volume in a given field (A) **CSO 3.5:**To define dielectric and its effect in capacitance(K+U) **CSO 3.6:**Workout problems based on dielectric medium (A) **CSO 3.7:**To define and discuss polarisation and displacement vector (K+U) **CSO 3.8:**To define and explain Biot-Savart's law (K+U) **CSO 3.9:**To discuss on the application of Biot-Savart's law different shapes of conductors (A) **CSO 3.10:**To work out problems	9	20	Not to be filled-in

		based on the application (A) **CSO 3.11:** To illustrate on divergence and curl of magnetic field (U+A) **CSO 3.12:** To derive magnetic vector from the divergence and curl of the field (A) **CSO 3.13:** To define and discuss Ampere's Circuital Law (K+U) **CSO 3.14:** To illustrate on the application of Circuital law (A)			
UNIT 4 **Magnetic properties of materials and Electromagnetic Induction**	Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro-magnetic materials. **Electromagnetic Induction:** Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic Field. Transformer, Auto Transformer, different losses of transformer.	**CSO 4.1:**To define the various magnetic properties like intensity, induction, permeability, susceptibility (K) **CSO 4.2:**To explain the relationship between the magnetic properties mentioned (U+A) **CSO 4.3:**To define dia, para and ferromagnetic materials (K) **CSO 4.4:**To compare the various magnetic material (U+A) **CSO 4.5:** To define electromagnetic induction (K) **CSO 4.6:**To define and discuss Faraday's laws in electromagnetic induction(K+U) **CSO 4.7:**To study the modification given by Lenz (Lenz's law) **CSO 4.8:**To define and derive self and mutual inductance (K+A) **CSO 4.9:**To compare and contrast self and mutual inductance (U+A) **CSO 4.10:**To illustrate on Self-inductance in single coil and mutual inductance on two coil (A) **CSO 4.11:**To workout problems based on self and mutual inductance (A) **CSO 4.12:**To define Transformers and discuss on it construction and working principle (K+U+A) **CSO 4.13:**To discuss on types of transformer (U) **CSO 4..14:** To discuss on the losses of transformer (K+U)	9	20	Not to be filled-in
UNIT 5 **Maxwell`s equations and Electromagnetic wave propagation**	Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field,	**CSO 5.1:**To discuss on the various Maxwell's equation (K+U) **CSO 5.2:**To define and derive the equation of continuity of current (K+A) **CSO 5.3:**To illustrate on Maxwell's equations and modify it using the continuity equation (A)	9	20	Not to be filled-in

	electromagnetic wave propagation through vacuum.	**CSO 5.4:**To define Poynting vector and discuss it significance (K+U) **CSO 5.5:**To discuss on energy density in electromagnetic field (U+A) **CSO 5.6:**To explain and derive the equation of electromagnetic wave propagation through vacuum (U+A)			

SUGGESTED READINGS:

1. S. Mahajan and Choudhury, *Electricity, Magnetism & Electromagnetic Theory*, Tata McGraw, 2012.
2. Edward M. Purcell, *Electricity and Magnetism*, McGraw-Hill Education, 1986 .
3. D.J. Griffiths, *Introduction to Electrodynamics*, 3rd Edn., Benjamin Cummings, 1998.
4. R.P.Feynman, R.B.Leighton, M. Sands, *Feynman Lectures Vol.2*, Pearson Education 2008.
5. M.N.O. Sadiku, *Elements of Electromagnetics*, Oxford University Press ,2010.
6. J.H.Fewkes&J.Yarwood ,*Electricity and Magnetism*, Vol. I, Oxford Univ. Press 1991.

Semester	II
Paper Code	PHM 2(P)
Paper Title	Electricity and Magnetism
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Demonstration and practical laboratory experiments on electrical circuits and devices and uses of different electrical devices is the objective of the course. Moreover, raining on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors is also an aim of the course.

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. To determine the specific resistance by metre bridge.
3. To determine the strength of the magnetic field produced at the centre of the tangent galvanometer coil due to a current flowing in it and hence to determine horizontal component of earth‘s magnetic field.

1. To determine the self induction of a coil and its internal resistance in an L-R circuit
2. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
3. To determine the resistance of a galvanometer by half deflection method.
4. To determine a resistance per unit length of metre bridge wire by Carey Foster‘s method.
5. To verify the Thevenin and Norton theorem.
6. To verify series and parallel laws of resistance by Post office Box.
7. To compare the emf of two cells by potentiometer.

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House , 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers, reprinted, 1985.
3. S. Panigrahi and B. Mallick, *Engineering Practical Physics*, Cengage Learning, 2015.
4. D. P. Khandelwal, *A Laboratory Manual of Physics for undergraduate classes,*Vani Pub, 1985.

Semester-III

Semester	III
Paper Code	PHM 3
Paper Title	Thermal Physics and Statistical Mechanics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Thermal Physics and Statistical Mechanics**:

CO 1:	To study the laws of thermodynamics.
CO 2:	To learn the thermodynamic potentials.
CO 3:	To study the kinetic theory of gases.
CO 4:	To understand the theory of radiation.
CO 5:	To learn the basics of statistical mechanics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Laws of Thermodynamics**	**Thermodynamic Description of system**: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermo dynamical Processes, Applications of First Law: General Relation between CP & CV, Work Done during Isothermal and Adiabatic Processes,	**CSO 1.1:** To define thermodynamics.(K) **CSO 1.2:** To explain the Zeroth law of thermodynamics.(U) **CSO 1.3:** To define temperature.(K) **CSO 1.4:** To explain the first law of thermodynamics.(U) **CSO 1.5:** To define internal energy.(K) **CSO 1.6:** To define heat and work and explain its conversion.(K&U) **CSO 1.7:** To study the various thermodynamical	11	24	Not to be filled-in

	Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics.	processes.(U) **CSO 1.8:** To study the application of first law to thermodynamical processes.(A) **CSO 1.9:** To define specific heat at constant pressure and volume and derive the relation between them. (K&U) **CSO 1.10:** To derive the formula for work done during isothermal and adiabatic process. **CSO 1.11:** To define compressibility and expansion coefficient.(K) **CSO 1.12:**To define reversible & irreversible processes.(K) **CSO 1.13:** To explain second law of thermodynamics. (U) **CSO 1.14:**To define entropy .(K) **CSO 1.15:**To explain Carnot's cycle & theorem.(U) **CSO 1.16:** To understand the entropy changes in reversible & irreversible processes.(U) **CSO 1.17:** To explain entropy-temperature diagrams. (U) **CSO 1.18:**To learn the third law of thermodynamics.(U)			
UNIT 2 Thermodynamic Potentials	Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations.	**CSO 2.1:** To define the thermodynamic potentials(Enthalpy, Gibbs, Helmholtz and Internal Energy functions).(K) **CSO 2.2:** To derive Maxwell's relations.(A) **CSO 2.3:** To learn the application of Maxwell's relations to Joule-Thompson effect and Clausius-Clapeyron equation.(A) **CSO 2.4:** To derive the expression for (CP – CV).(U) **CSO 2.5:** To derive the expression for CP/CV.(U)	9	20	Not to be filled-in

		CSO 2.6: To derive TdS equations. (A)			
UNIT 3 Kinetic Theory of Gases	Derivation of Maxwell‘s law of distribution of speeds and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.	**CSO 3.1:** To derive Maxwell‘s law of distribution of speeds and explain its experimental verification. **CSO 3.2:** To explain mean free path.(U) **CSO 3.3:** To define Transport Phenomena.(K) **CSO 3.4:** To derive the Transport Phenomena formula for Viscosity, Conduction and Diffusion (for vertical case).(A) **CSO 3.5:** To derive the law of equipartition of energy.(A) **CSO 3.6:** To study the application of law of equipartition of energy to specific heat of gases.(A)	9	20	Not to be filled-in
UNIT 4 **Theory of Radiation**	Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien‘s distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien‘s displacement law from Planck‘s law.	**CSO 4.1:** To define radiation.(K) **CSO 4.2:**To define Blackbody radiation.(K) **CSO 4.3:** To explain Spectral distribution.(U) **CSO 4.4:**To explain the Concept of Energy Density.(U) **CSO 4.5:** To derive Planck's law, Wien‘s distribution law, Rayleigh-Jeans Law.(A) **CSO 4.6:**To derive Stefan Boltzmann Law and Wien‘s displacement law from Planck‘s law.(A)	8	18	Not to be filled-in
UNIT 5 Statistical Mechanics	Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law, Bose-Einstein distribution law	**CSO 5.1:** To define statistical mechanics.(K) **CSO 5.2:** To define macrostate and microstate with examples. (K&A) **CSO 5.3:** To explain entropy and thermodynamic probability.(U) **CSO 5.4:** To derive Maxwell-Boltzmann law - distribution of velocity.(A) **CSO 5.5:**To explain the difference between Quantum statistics and	8	18	Not to be filled-in

		Fermi-Dirac statistics.(U) **CSO 5.6:** To derive the Fermi-Dirac distribution law.(A) **CSO 5.7:** To derive the Fermi-Dirac distribution law.			

SUGGESTED READINGS:

1. M.W. Zemansky, Richard Dittman, *Heat and Thermodynamics*, McGraw-Hill, 1981.
2. MeghnadSaha, and B.N.Srivastava, *A Treatise on Heat*, Indian Press, 1958.
3. S. Garg, R. Bansal and Ghosh, *Thermal Physics*, 2nd Edition, Tata McGraw-Hill, 1993.
4. Carl S. Helrich, *Modern Thermodynamics with Statistical Mechanics*, Springer, 2009.
5. Sears & Salinger, *Thermodynamics, Kinetic Theory & Statistical Thermodynamics*, Narosa, 1988.
6. S.J. Blundell and K.M. Blundell, *Concepts in Thermal Physics*, 2nd Ed., Oxford University Press, 2012.
7. A. Kumar and S.P. Taneja, *Thermal Physics*, R. Chand Publications, 2014.

Semester	III
Paper Code	PHM 3 (P)
Paper Title	Thermal Physics and Statistical Mechanics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The objective of this lab coursework is to observe certain laws that have been learnt in theory classes.

1. To determine Mechanical Equivalent of Heat, J, by Joule‘s method.
2. To determine the specific heat of a liquid by the method of cooling.
3. To verify Stefan‘s law by electrical method.
4. To determine the coefficient of thermal conductivity of copper by Searle‘s Apparatus.
5. To determine the coefficient of linear expansion by suitable method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
7. To study the variation of thermoemf across two junctions of a thermocouple with temperature.

SUGGESTED READINGS:

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

Semester-IV

Semester	IV
Paper Code	PHM 4
Paper Title	Elements of Modern Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Elements of modern physics**:

CO 1:	To make the students understand historical development of quantum theory , from Planck's quantum hypothesis to Bohr's model of the atom and explaining the limitations of classical models and appreciate the quantum concepts of the behaviour at the atomic scale.
CO 2:	To understand the foundational principles of quantum mechanics, including the challenges associated with the position measurement, wave particle duality and limitation imposed by the Heisenberg uncertainty principle.
CO 3:	To create an understanding among the students about the principle quantum mechanics, including wave particle duality, interference and interpret various phenomena at the quantum level using Schrodinger equation and probability concept.
CO 4:	To create comprehensive understanding of quantum mechanical phenomena in confined system, scattering and tunnelling and should be familiar with the nuclear forces, the liquid drop model, and the nuclear shell model, providing insight into the structure and stability of atomic nuclei.
CO 5:	To aid the student in understanding the principle underlying radioactivity, nuclear reactions and energy generation through fusion and fission and appreciate the implication for energy production and nuclear technologies.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Introduction to quantum mechanics through Planck's equation	Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy	**CSO 1.1:** To understand Planck's quantum hypothesis.(U) **CSO 1.2:** To define Planck's constant and its significance.(K) **CSO 1.3:** To determine light as a collection of photons.(A) **CSO 1.4:** To understand the photoelectric effect and its experiment.(U) **CSO 1.5:** To understand how photoelectric effect support the particle nature of light. (U) **CSO 1.6:** To understand Compton scattering and its implication for the particle like behaviour of photons.(U) **CSO 1.7:** To define and	9	18	Not to be filled-in

	levels for hydrogen like atoms and their spectra	calculate the de Broglie wavelength.(K) **CSO 1.8:** To understand the concept of matter waves.(U) **CSO 1.9:** To explain the Davisson-Germer experiment.(U) **CSO 1.10:**To understand how the experiment provided evidence for the wave nature of electrons.(U) **CSO 1.11:** To discuss limitation and problem with the Rutherford model of the atom.(U) **CSO 1.12:** To describe instability of electron in classical orbits.(K) **CSO 1.13:** To explain the observation of discrete atomic spectra.(U) **CSO 1.14:** To derive Bohr's quantization rule for electron orbit.(A) **CSO 1.15:** To discuss how Bohr model addresses the stability of atom.(U) **CSO 1.16:** To understand and derive the quantized energy level in Bohr's model.(U) **CSO 1.17:** To calculate energy level foe hydrogen-like atom and explain their spectra.(A)			
UNIT 2 **Position measurement and Heisenberg uncertainty principle**	Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	**CSO 2.1:** To understand the challenges and limitation associated with the precisely measuring the position of particles.(U) **CSO 2.2:** To analyse the gamma ray microscope thought experiment and its position measurement.(A) **CSO 2.3:** To explain the concept of wave-particle duality. (U) **CSO 2.4:** To understand the particles exhibit both wave-like and particle-like characteristics.(U) **CSO 2.5:** To derive the Heisenberg uncertainty principle.(A) **CSO 2.6:**To discuss the impossibility of determining both the position and momentum of a	9	20	Not to be filled-in

		particle simultaneously.(U) **CSO 2.7:** To apply the uncertainty principle to estimate the minimum energy of a confined particles.(A) **CSO 2.8:** To understand the connection between position uncertainties and energy uncertainties.(U) **CSO 2.9:** To derive the energy-time uncertainty principles.(A) **CSO 2.10:** To discuss the energy-time uncertainty principle for the energy and time measurement in quantum mechanics. (U)			
UNIT 3 **Schrodinger equation for non-relativistic particles; probabilities and normalization**	Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave function , probabilities and normalization; Probability and probability current densities in one dimension	**CSO 3.1:**To understand the basic concept of two-slit interference experiment.(U) **CSO 3.2:**To explore how interference patterns differ when conducting the experiment with photons, atoms and particles.(A) **CSO 3.3:**To define and understand the linear superposition principle.(K) **CSO 3.4:**To explain the concept of matter waves.(U) **CSO 3.5:**To understand wave amplitude and its significance in describing the behaviour of particles at the quantum level.(U) **CSO 3.6:**To derive and understand the Schrodinger equation for nonrelativistic particles.(A) **CSO 3.7:**To understand the role of wave function in describing the quantum state of a system.(U) **CSO 3.8:**To define momentum and energy operators in the context of quantum mechanics.(K) **CSO 3.9:**To understand the concept of stationary states and their significance in Schrodinger's equations.(U) **CSO 3.10:**To discuss the physical interpretation of wave functions.(U) **CSO 3.11:**To understand how probabilities are related to the	8	20	Not to be filled-in

		square of the wave functions.(U) **CSO 3.12:**To define probability density and probability current density.(K) **CSO 3.13:** To explore the concept of probability density in one dimension and its relationship to the wave function.(A)			
UNIT 4 **Quantum mechanics, nuclear physics and atomic structure**	One dimensional infinitely rigid box-energy eigen values and igen functions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.	**CSO 4.1:**To understand the concept of an infinitely rigid box in quantum mechanics.(U) **CSO 4.2:**To calculate energy eigen values and eigen functions for a particle confined in a one-dimensional box.(A) **CSO 4.3:**To discuss the normalization wave function.(U) **CSO 4.4:**To explain the concept of quantum dots.(U) **CSO 4.5:**To analyse quantum mechanical scattering phenomena.(A) **CSO 4.6:**To understand tunnelling through potential barriers, both step potential and rectangular potential.(U) **CSO 4.7:**To explore the size and structure of atomic nuclei.(A) **CSO 4.8:** To understand the relationship between the size and structure of the nucleus and the atomic weight.(U) **CSO 4.9:** To explore the nature of nuclear forces.(A) **CSO 4.10:**To understand the NZ graph, which represents the number of neutrons versus photons in stable nuclei.(U) **CSO 4.11:**To explore the semi-empirical mass formula and understand its components including binding energy.(A)	10	20	Not to be filled-in
UNIT 5 **Radioactivity**	stability of nucleus; Law of radioactive decay; Mean life and half-life; decay; decay - energy released, spectrum an d Pauli's prediction of neutrino; -ray emission. Fission and fusion - mass deficit, relativity and generation of	**CSO 5.1:**To understand the factors influencing the stability of atomic nuclei.(U) **CSO 5.2:**To explain the role of forces within the nucleus in maintaining stability.(U) **CSO 5.3:**To discuss the law of radioactive decay.(U) **CSO 5.4:**To define and calculate mean life and half-life of radioactive substance.(K)	9	22	Not to be filled-in

	energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions	**CSO 5.5:**To explain the process of alpha decay.(U) **CSO 5.6:**To understand the characteristics of alpha particles emitted during the decay.(U) **CSO 5.7:**To discuss energy released in beta decay.(U) **CSO 5.8:**To explore the beta decay spectrum and the role neutrons, as predicted by Pauli.(A) **CSO 5.9:**To understand the emission of gamma rays in nuclear processes.(U) **CSO 5.10:**To discuss the properties and characteristics of gamma ray.(U) **CSO 5.11:**To explain the concept of mass deficit in nuclear reaction.(U) **CSO 5.12:**To understand the role of relativity in explaining mass-energy equivalence.(U) **CSO 5.13:**To discuss the generation of energy in nuclear fission and fusion reaction.(A) **CSO 5.14:**To describe the nature if fragments produced in nuclear fission.(K) **CSO 5.15:**To understand the significance of neutron emission in fission reaction.(U) **CSO 5.16:**To explain the basic principle if nuclear reactor.(U) **CSO 5.17:** To understand the role of sloe neutron in sustaining a chain reaction in uranium-235.(U) **CSO 5.18:** To discuss the principle of fusion reactions and their role in stellar energy production.(U) **CSO 5.19:** To explain the condition required for thermonuclear reaction.(U)			

SUGGESTED READINGS:

1. Arthur Beiser, *Concepts of Modern Physics*, McGraw-Hill, 2002.
2. Rich Meyer, Kennard, Coop, *Introduction to Modern Physics*, Tata McGraw Hill, 2002.
3. David J. Griffith, *Introduction to Quantum Mechanics*, Pearson Education, 2005.
4. Jewett and Serway, *Physics for scientists and Engineers with Modern Physics*, Cengage Learning, 2010.
5. R.A. Serway, C.J. Moses, and C.A.Moyer, *Modern Physics*, Cengage Learning , 2005.
6. G. Kaur and G.R. Pickrell, *Modern Physics*, McGraw Hill ,2014.

Semester	IV
Paper Code	PHM 4(P)
Paper Title	Elements of Modern physics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The student will get the opportunity to measure Planck's constant, to find the Boltzmann constant value using V-I characteristics, they will also find wavelength of laser source by single and double slit experiment, find the value of e/m by magnetic focusing or bar magnet.

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of fi lament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor& compare with incoherent source – Na.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House, 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers, 1985.
3. I.Prakash& Ramakrishna, *A Text Book of Practical Physics*, 11th Edn,Kitab Mahal, 2011.

Semester- V

Semester	V
Paper Code	PHM 5
Paper Title	Solid State Physics
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Solid state physics**:

CO 1:	To make the students understand the basic concept of the crystal structure.
CO 2:	To aid the students in the understanding of Elementary Lattice Dynamics.
CO 3:	To create an understanding among the students about different magnetic materials and their properties.
CO 4:	To inculcate and create interest among students in the understanding of Dielectric properties of materials and Ferroelectric Properties of Materials
CO 5:	To assist the students in the understanding of Elementary band theory and superconductors

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 Crystal Structure	Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law.	**CSO 1.1:** To identify Amorphous and Crystalline Materials. (K) **CSO 1.2:** To describe lattice translations vectors. (K) **CSO 1.3:** To define basis and unit cell (K). **CSO 1.4:** To discuss Miller indices. (U) **CSO 1.5:** To discuss the concept of reciprocal lattice. (U) **CSO 1.6:** To classify different types of lattices. (U) **CSO 1.7:** To define the Brillouin zones and discuss its derivations. (K) **CSO 1.8:** To derive the diffraction of x-rays of crystals. (A) **CSO 1.9:** To define Bragg's law. (K) **CSO 1.10:** To construct the reciprocal lattice for simple cubic, face centered cubic and body centered cubic structure. (A) **CSO 1.11:** To differentiate between simple cubic, face centered cubic and body centered cubic structure **CSO 1.12:** To derive Bragg's equation. (A)	9	20	Not to be filled-in
UNIT 2 Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of	**CSO 2.1:** To discuss the concept of lattice vibrations and phonons. **CSO 2.2:** To construct the lattice vibrational mode for monoatomic crystal. (A) **CSO 2.3:** To construct the lattice vibrational mode for diaoatomic crystal. (A) **CSO 2.4:** To define	8	19	Not to be filled-in

	specific heat of solids. T^3 law	acoustical and optical phonons. (K) **CSO 2.5:** To discuss the description of the phonon spectrum in solids. (U) **CSO 2.6:** To state Dulong and Petit's Law. (K) **CSO 2.7:** To describe Einstein and Debye theories of specific heat of solids. (K) **CSO 2.8:** To derive the Dulong and Petit's law. (A) **CSO 2.9:** To construct Einstein theory of specific heat of solid. (A) **CSO 2.10:** To construct Debye theory of specific heat of solid. (A) **CSO 2.11:** To define T^3 law. (K) **CSO 2.12:** To derive the T^3 Law			
UNIT 3 **Magnetic properties of matter**	Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve.	**CSO 3.1:** To define Dia, Para, Ferri and Ferromagnetic materials. (K) **CSO 3.2:** To derive the classical Langevin theory of Dia- and paramagnetic magnetism. (A) **CSO 3.3:** To analyse the quantum mechanical treatment of paramagnetism. (A) **CSO 3.4:** To state Curie's law. (K) **CSO 3.5:** To construct Weiss's theory of Ferromagnetism and Ferromagnetic domains. (A) **CSO 3.6:** To illustrate the B-H curve of ferromagnetic material. (A) **CSO 3.7:** To differentiate between	8	19	Not to be filled-in

		Dia-, Para-, Ferri- and Ferromagnetic materials. (U) **CSO 3.8:** To define domains. (K)			
UNIT 4 **Dielectric properties of materials and Ferroelectric Properties of Materials**	Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons. **Ferroelectric Properties of Materials**: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Ferroelectric domains, PE hysteresis loop.	**CSO 4.1:** To define polarization. (K) **CSO 4.2:** To explain local electric field of an atom. (U) **CSO 4.3:** To define depolarization field. (k) **CSO 4.4:** To define electric susceptibility. (K) **CSO 4.5:** To define polarizability. (K) **CSO 4.6:** To derive and explain Clausius Mosotti equation. (A) **CSO 4.7:** To explain classical theory of electric polarizability. (U) **CSO 4.8:** To define and discuss normal and anomalous dispersion. (U) **CSO 4.9:** To construct Cauchy and Sellmeir relations. (A) **CSO 4.10:** To derive Langevin- Debye equation. (A) **CSO 4.11:** To discuss optical phenomena. (U) **CSO 4.12:** To describe plasma oscillations, plasma frequency, plasmons. (K) **CSO 4.13:** To define and explain ferroelectric properties of materials. (U)	11	22	Not to be filled-in
UNIT 5 **Elementary band theory and superconductivity.**	**Elementary band theory:** Kronig Penny model. Band Gap. Conductor, Semiconductor and insulator. Conductivity of Semiconductor, mobility, Hall Effect and Hall coefficient. **Superconductivity**:	**CSO 5.1:** To define and explain the elementary band theory. (K) **CSO 5.2:** To construct Kronig Penny model. (A) **CSO 5.3:** To explain band gap. (U) **CSO 5.4:** To define conductor, semiconductor and	9	20	Not to be filled-in

	Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London‘s Equation. Isotope effect.	insulator. (K) **CSO 5.5:** To explain the conductivity of semiconductor, mobility, hall effect and hall coefficient. (U) **CSO 5.6:** To define superconductivity. (A) **CSO 5.7:** To discuss critical temperature and critical magnetic field. (U) **CSO 5.8:** To discuss Meissner effect. (U) **CSO 5.9:** To derive London’s equation. (A) **CSO 5.10:** To determine the Isotope effect of superconductors. (U)			

SUGGESTED READINGS:

1. Charles Kittel, *Introduction to Solid State Physics*, 8th Edition, Wiley India Pvt. Ltd, 2004.
2. J.P. Srivastava, *Elements of Solid State Physics*, 4th Edition, Prentice-Hall of India, 2015.
3. Leonid V. Azaroff, *Introduction to Solids*, Tata Mc-Graw Hill, 2004.
4. N.W. Ashcroft and N.D. Mermin, *Solid State Physics*, Cengage Learning, 1976.
5. H. Ibach and H. Luth, *Solid-state Physics*, Rita John, *Springer Solid State Physics*, McGraw Hill 2009, 2014.
6. 1/e M. Ali Omar, *Elementary Solid State Physics*, Pearson India, 1999.
7. M.A. Wahab, *Solid State Physics*, Narosa Publications, 2011.

Semester	V
Paper Code	PHM 5(P)
Paper Title	Solid State Physics
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

The aim and objective of the lab course is to introduce the students to the formal structure of solid state physics so that they can use these as per their requirement.

1. Measurement of susceptibility of paramagnetic solution by (Quinck`s Tube Method)/suitable method.
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Material by suitable method.
4. To study the PE Hysteresis loop of a Ferroelectric Crystal.
5. To draw the BH curve of Fe using Solenoid/transformer & determine energy loss from Hysteresis.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ◦C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

SUGGESTED READINGS:

1. B.L. Flint and H.T. Worsnop, *Advanced Practical Physics for students*, Asia Publishing House, 1971.
2. Michael Nelson and Jon M. Ogborn, *Advanced level Physics Practicals*, 4th Edition, Heinemann Educational Publishers, reprinted 1985.
3. I. Prakash& Ramakrishna, *A Text Book of Practical Physics*, 11th Ed., Kitab Mahal, 2011.
4. J.P. Srivastava, *Elements of Solid State Physics*, 2nd Ed., Prentice-Hall of India, 2006.

Semester-VI

Semester	VI
Paper Code	PHM 6
Paper Title	Nuclear and Particle Physics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Nuclear and Particle Physics**:

CO 1:	To understand the basic properties of the nucleus.
CO 2:	To analyse different nuclear models.
CO 3:	To make the students understand the concept of radioactivity and nuclear reactions.
CO 4:	To understand the working of nuclear detectors and counters.
CO 5:	To make the students understand the different types of particles and the conservation laws related to them.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 General Properties of Nuclei	Constituents of nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter energy), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric	**CSO 1.1:** To define nucleus.(K) **CSO 1.2:** To understand the constituents that made up a nucleus.(U) **CSO 1.3:** To learn the different intrinsic properties of the nucleus .(U) **CSO 1.4:** To define binding energy and explain its variation with mass number.(K&A) **CSO 1.5:** To discuss the classification of nuclei.(U) **CSO 1.6:** To understand the concept of nuclear force.(U)	11	18	Not to be filled-in

	moments, nuclear excites states, concept of nuclear force.				
UNIT 2 Nuclear Models	Liquid drop model approach, Fermi gas model ,semi empirical mass formula and significance of various terms, condition of nuclear stability,evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model.	**CSO 2.1:** To explain the Liquid Drop model.(U) **CSO 2.2:** To explain the Fermi Gas model.(U) **CSO 2.3:** To explain the semi empirical mass formula and the significance of the various terms in the formula. (U) **CSO 2.4:** To explain the condition of nuclear stability.(U) **CSO 2.5:** To explain the evidence of nuclear shell structure. (U) **CSO 2.6:** To define magic numbers .(K) **CSO 2.7:** To explain the shell model using the concept of magic numbers. (U)	13	22	Not to be filled-in
UNIT 3 Radioactivity	(a) Alpha decay: basics of α-decay processes, qualitative idea of alpha emission theory, Geiger Nuttall law, (b) Beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate.	**CSO 3.1:** To define radioactivity .(K) **CSO 3.2:** To define radioactivity decay.(K) **CSO 3.3:** To define alpha, beta and gamma rays.(K) **CSO 3.4:** To define alpha decay.(K) **CSO 3.5:** To discuss the basics of alpha decay processes.(U) **CSO 3.6:** To discuss the qualitative idea of alpha emission theory.(U) **CSO 3.7:** To explain the Geiger Nuttal law.(U) **CSO 3.8:** To define beta decay.(K) **CSO 3.9:** To derive the energy kinematics for different types of beta decay.(A) **CSO 3.10:** To explain the neutrino hypothesis.(U) **CSO 3.11:** To define gamma decay.(K) **CSO 3.12:** To explain the different types of gamma decay processes.(U) **CSO 3.13:** To define nuclear reactions.(K) **CSO 3.14:** To define the different types of nuclear reactions.(K) **CSO 3.15:** To discuss the conservation laws related to nuclear reactions.(U) **CSO 3.16:** To derive the Q-Value of nuclear reactions.(A)	14	24	Not to be filled-in

UNIT 4 Detector for Nuclear Radiations	Ionization chamber, proportional counter and GM Counter. Basic principle of Scintillation Detectors and construction of Photo-Multiplier Tube (PMT). **Particle Accelerators:** Van-de Graaff generator, Linear accelerator, Cyclotron	**CSO 4.1:** To define detector.(U) **CSO 4.2:** To explain the Ionization Chamber.(U) **CSO 4.3:** To explain the Proportional Counter.(U) **CSO 4.4:** To explain the GM Counter.(U) **CSO 4.5:** To explain Scintillation Detector.(U) **CSO 4.6:** To explain Photo Multiplier tube. (U) **CSO 4.7:** To define accelerators.(K) **CSO 4.8:** To explain Vande-Graff generator.(U) **CSO 4.9:** To explain Linear Accelerator.(U) **CSO 4.10:** To define Cyclotron.(K) **CSO 4.11:** To explain the Cyclotron.(U)	12	20	Not to be filled-in
UNIT 5 Particle physics	Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model.	**CSO 5.1:** To define particle Physics.(K) **CSO 5.2:** To define elementary particles.(K) **CSO 5.3:** To explain the classification of elementary particles.(U) **CSO 5.4:** To discuss the fundamental interactions associated with the elementary particles. (A) **CSO 5.5:** To explain the intrinsic quantum numbers associated with elementary particles. (U) **CSO 5.6:** To explain the conservation laws associated with the elementary particles.(U) **CSO 5.7:** To explain the symmetries related to conservation laws.(U) **CSO 5.8:** To define quark.(K) **CSO 5.9:** To explain the quark model.(U)	10	16	Not to be filled-in

SUGGESTED READINGS:

1. Kenneth S. Krane ,*Introductory nuclear Physics* ,Wiley India Pvt. Ltd., 2008.
2. Bernard L. Cohen ,*Concepts of nuclear physics*, Tata Mc graw Hill, 1998.
3. R.A. Dunlap, *Introduction to the physics of nuclei & particles*, Thomson Asia, 2004.
4. K. Heyde, *Basic ideas and concepts in Nuclear Physics - An Introductory Approach* ,IOP- Institute of Physics Publishing, 2004.
5. G.F. Knoll , *Radiation detection and measurement*, John Wiley & Sons, 2000.
6. J.M. Blatt &V.F.Weisskopf , *Theoretical Nuclear Physics,* Dover Pub.Inc., 1991.

Semester-VII

Semester	VII
Paper Code	PHM 7
Paper Title	Digital, Analog and Instrumentation
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Digital, Analog and Instrumentation**:

CO 1:	To instill an idea on Digital Circuits among the students
CO 2:	To create an awareness among the students on Semiconductor Devices, Amplifiers and Bipolar Junction transistors
CO 3:	To let the students understand the concepts of Operational Amplifiers and Sinusoidal Oscillators
CO 4:	To inculcate and create interest among students in Instrumentations
CO 5:	To assist the students in understanding Power Supply and Timer IC

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Digital Circuits**	Binary Numbers Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor).NAND and NOR Gates as Universal Gates.XOR and XNOR Gates.De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Max terms. Conversion of a Truth Table into an Equivalent Logic Circuit by Sum of Products Method and Karnaugh Map. Binary Addition. Binary Subtraction using 2's Complement Method. Half Adders and Full	**CSO 1.1:**To define digital circuits. (K) **CSO 1.2:**To discuss on the various number systems and their interconversions .(U+A) **CSO 1.3:**To introduce to logic gates and its applications.(U+A) **CSO 1.4:**To discuss on De Morgan's theorem.(U+A) **CSO 1.5:**To introduce to Booleans law and simplify equations .(U+A) **CSO 1.6:**To discuss K-Map and simplify problems using the same.(K+U+A) **CSO 1.7:**To discuss on 2's complement and perform binary addition and subtraction. (A) **CSO 1.8:**To define and explain half adder, full adder, half subtractor and full subtractor. (K+U+A)	11	24	Not to be fille d-in

	Adders and Subtractors,4-bit binary Adder Subtractor.				
UNIT 2 Semiconductor Devices and Amplifiers and Bipolar Junction transistors	Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Principle and structure of LEDs, Photodiode and Solar Cell. **Bipolar Junction transistors:** n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cut off & Saturation regions Current gains α and β.Relations between α and β. Load Line analysis of Transistors. DC Load line &	**CSO 2.1:**To define semiconductors .(K) **CSO 2.2:**To discuss the types of semiconductors.(U) **CSO 2.3:**To explain on the formation of barrier in p-n junction. (U) **CSO 2.4:**To define forward and reverse bias mode. (K) **CSO 2.5:**To explain on the current flow mechanism in forward and reverse bias mode. (U+A) **CSO 2.6:**To discus the VI characteristic curve if pn junction. (U) **CSO 2.7:**To define and discuss the principle and structure of LED, Photodiode and Solar Cell. (A+U) **CSO 2.8:**To define transistor.(K) **CSO 2.9:** To explain on the types of transistors and its characteristics in various modes. (U+A) **CSO 2.10:** To define and explain on power amplification factors .(K) **CSO 2.11:** To explain the relationship of α and β. (A) **CSO 2.12:** To discuss on the mechanism of current flow. (A+U)	11	24	Not to be fille d-in
UNIT 3 Operational Amplifiers and Sinusoidal Oscillators	Operational Amplifiers Applications of Op-Amps: (1)Inverting and non-inverting Amplifiers, (2)Adder,(3) Subtractor, (4)Differentiator, (5)Integrator Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator	**CSO 3.1:** To explain on inverting and non-inverting amplifiers.(U+A) **CSO 3.2:** To discuss on the use of op-amps as an adder, subtractor, differentiator, and integrator. (U+A) **CSO 3.3:** To explain Barkhausen's Criterion for Self-sustained oscillator. **CSO 3.4:** To define operational amplifier and its difference from normal amplifier .(U) **CSO 3.5:** To define RC coupled amplifier .(K) **CSO 3.6:** To determine the frequency of RC oscillator .(A)	11	23	Not to be fille d-in
UNIT 4	Introduction to CRO:	**CSO 5.1:** To define CRO. (K)	5	12	Not

Instrumentations	Block Diagram of CRO. Applications of CRO:(1)Study of Waveform,(2)Measurement of Voltage, Current, Frequency, and Phase Difference	**CSO 5.2:** To discuss the circuital diagram of CRO .(U) **CSO 5.3:** To study the Application of CRO for measurement of current, voltage. (U+A) **CSO 5.4:**To explain on how to study waveforms using CRO .(U)			to be fille d-in
UNIT 5 Power Supply and Timer IC	Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifier Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. **Timer IC**:IC555 Pin diagram and its application as A stable and Monostable Multivibrator.	**CSO 5.1:**To define power supply .(K) **CSO 5.2:** To define rectifiers. (K) **CSO 5.3:** To explain half wave and full wave rectifier. (U) **CSO 5.4:** To calculate the ripple factor and efficiency of the output of both half wave and full wave rectifier. (U+A) **CSO 5.5:** To define filters. (K) **CSO 5.6:**To study on the importance of filters in rectifiers .(U+A) **CSO 5.7:** To define and explain zener diode. (U) **CSO 5.8:** To explain on the application of Zener diode as a voltage regulator. (A+U) **CSO 5.9:** To define explain on timer IC 555. (K+U) **CSO 5.10:** To discuss on the pin diagram of the timer IC. (U) **CSO 5.11:** To explain on the application of timer IC. (A)	7	17	Not to be fille d-in

SUGGESTED READINGS:

1. J.Millmanand C.C.Halkias, *Integrated Electronics*, TataMc-GrawHill,1991.
2. S.Salivahanan&N.S.Kumar, *Electronic devices&circuits*, TataMc-GrawHill,2012.
3. M.H.Rashid, *Microelectronic Circuits*, 2ndEdn., CengageLearning,2011.
4. Tech., Helfrick and Cooper,*Modern Electronic Instrumentation and Measurement*,PHI Learning, 1990.
5. A.P.Malvino,D.P.LeachandSaha,*Digital Principles and Applications*, 7thEd., TataMcGrawHill 2011.
6. A.Anand Kumar,*Fundamentals of Digital Circuits*, 2ndEdition, PHI Learning Pvt.Ltd.,2009.
7. R.A.Gayakwad,*OP-AMP&Linear Digital Circuits*, PHI Learning Pvt.Ltd, 2000.

Semester	VII
Paper Code	PHM 7(P)
Paper Title	Digital, Analog and Instrumentation
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	01

Laboratory Objective:

Students will learn about combinational logic functions such as adders, multivibrator, etc and learn to design logic circuits.

1. To measure(a)Voltage,and(b)Frequency of a periodic wave form using CRO
2. To verify and design AND,OR,NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder,Full adder and 4-bit Binary Adder.
5. Adder-Subtractor using Full Adder I.C.
6. To design a stable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To study IV characteristics of PN diode,Zener and Light emitting diode
9. To study the characteristics of a Transistor in CE configuration.
10. To design a CE amplifier of given gain(mid-gain)using voltage divider bias.
11. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
12. To design an on-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
13. To study Differential Amplifier of given I/O specification using Op-amp.
14. To investigate a differentiator made using op-amp.
15. To design a Wien Bridge Oscillator using an op-amp.

SUGGESTED READINGS:

1. P.B.Zbar,A.P.Malvino,M.A.Miller ,*Basic Electronics:Atext lab manual*, Mc-Graw Hill.,1994.
2. J.D.Ryder, *Electronics:Fundamentals and Applications*,Prentice Hall, 2004.
3. R.A.Gayakwad,*OP-Amps&Linear Integrated Circuit*, 4th Edn, Prentice Hall ,2000.
4. Albert Malvino, *Electronic Principle*, TataMc-GrawHill ,2008.

Semester	VII
Paper Code	PHM 8
Paper Title	Biophysics
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Bio Physics**:

CO 1:	To make the students understand the building blocks and structure of living state as well as living state interactions.
CO 2:	To guide the students in the understanding of heat transfer mechanism in biomaterials and thermodynamics involved in living state.
CO 3:	To assist the students in learning about open systems. Chemical thermodynamics and diffusion and transport mechanisms.
CO 4:	To create an interest among students in the understanding Fluids.
CO 5:	To aid the students in the understanding of Bioenergetics and Molecular motors.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Building Blocks & Structure of Living State and Living State Interactions	**Building Blocks & Structure of Living State:** Atoms and ions, molecules essential for life, what is life. **Living State Interactions:** Forces and molecular bonds, electric & thermal interactions, electric dipoles, Casimir interactions, domains of physics in biology.	**CSO 1.1:** To define atoms and ions. (K) **CSO 1.2:** To describe molecules essential for life. (K) **CSO 1.3:** To discuss what is life. (U) **CSO 1.4:** To describe forces and molecular bonds. (K) **CSO 1.5:** To explain electric and thermal interactions. (U) **CSO 1.6:** To evaluate electric dipoles. (A) **CSO 1.7:** To discuss Casimir interactions. (U) **CSO 1.8:** To discuss the domains of physics in biology. (U)	15	23	Not to be filled-in
UNIT 2 Heat Transfer in biomaterials and Living State Thermodynamics	**Heat Transfer in biomaterials:** Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **Living State Thermodynamics:** Thermodynamic equilibrium, first law of thermodynamics	**CSO 2.1:** To explain heat transfer mechanism. (U) **CSO 2.2:** To derive the heat equation. (A) **CSO 2.3:** To discuss Joule heating of tissue. (U) **CSO 2.4:** To describe thermodynamic equilibrium. (K)	17	25	Not to be filled-in

	and conservation of energy. Entropy and second law of thermodynamics, Physics of many particle systems, two state systems, continuous energy distribution, Casimir contribution of free energy	**CSO 2.5:** To state and define the first law of thermodynamics. (K) **CSO 2.6:** To discuss the conservation of energy. (U) **CSO 2.7:** To explain entropy and the second law of thermodynamics. (U) **CSO 2.8:** To determine the physics of many particles system. (A) **CSO 2.9:** To discuss two state systems. (U) **CSO 2.10:** To explain continuous energy distribution. (U) **CSO 2.11:** To examine Casimir contribution of free energy. (A)			
UNIT 3 **Open systems, chemical thermodynamics, Diffusion and transport**	**Open systems and chemical thermodynamics:** Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis& synthesis, Entropy of mixing, The grand canonical ensemble, Haemoglobin. **Diffusion and transport:** Maxwell-Boltzmann statistics, Fick's law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation	**CSO 3.1:** To define enthalpy. (K) **CSO 3.2:** To define Gibbs free energy. (K) **CSO 3.3:** To define chemical potential. (K) **CSO 3.4:** To describe activation energy and rate constants. (K) **CSO 3.5:** To explain enzymatic reactions. (U) **CSO 3.6:** To explain ATP hydrolysis and synthesis. (U) **CSO 3.7:** To discuss entropy of mixing. (U) **CSO 3.8:** To describe the grand canonical ensemble. (K) **CSO 3.9:** To define and describe haemoglobin. (K) **CSO 3.10:** To deduce the Maxwell Boltzmann statistics. (A) **CSO 3.11:** To explain Fick's law of diffusion. (U) **CSO 3. 12:** To discuss sedimentation of cell cultures. (U) **CSO 3.13:** To examine diffusion in a centrifuge. (A) **CSO 3.14:** To examine	15	23	Not to be filled-in

		diffusion in an electric field. (A) **CSO 3.15:** To examine diffusion in membranes. (A) **CSO 3.16:** To derive the Navier stokes equation. (A)			
UNIT 4 **Fluids**	Laminar and turbulent fluid flow, Bernoulli's equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action.	**CSO 4.1:** To define and describe laminar and turbulent fluid flow. (K) **CSO 4.2:**To derive Bernoulli's equation. (A) **CSO 4.3:**To derive equation of continuity. (A) **CSO 4.4:**To explain Venture effects (U) **CSO 4.5:**To discuss fluid dynamics of circulatory systems. (U) **CSO 4.6:**To explain capillary action. (U)	8	14	Not to be filled-in
UNIT 5 **Bioenergetics and Molecular motors**	Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules	**CSO 5.1:**To describe Kinesins. (K) **CSO 5.2:**To describe Dyneins. (K) **CSO 5.3:**To describe microtubule dynamics. (K) **CSO 5.4:**To explain Brownian motion. (U) **CSO 5.5:**To discuss ATP synthesis in Mitochondria. (U) **CSO 5.6:**To discuss photosynthesis in Chloroplasts. (U) **CSO 5.7:**To explore light absorption in biomolecules. (A)	8	15	Not to be filled-in

SUGGESTED READINGS:

1. J. Claycomb,*Introductory Biophysics*, JQP Tran, Jones & Bartelett Publishers.
2. Hughe S W, *Aspects of Biophysics*, John Willy and Sons.
3. P Narayanan ,*Essentials of Biophysics* , New Age International.

Semester-VIII

Semester	VIII
Paper Code	PHM 9
Paper Title	Earth Science
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Earth science**:

CO 1:	To make the students understandprevailing scientific theories and evidence regarding the origin and evolution of the universe, creation of elements and earth, energy and particle fluxes incident on the earth and the characteristic of the universe.
CO 2:	To understand the behaviour and structure of the earth, hydrosphere, atmosphere, cryosphere and biosphere including the plants and animals diversity.
CO 3:	To create an understanding among the students aboutdynamical process outcomes of earth's providing the process shaping earth system, including interaction between solid earth, hydrosphere, atmosphere and biosphere and their influence in global geophysical and environmental phenomena.
CO 4:	To aid an concept on evolution and concept of time in geological studies and understand the geochronological method and history of development in uniformitsrianism, catastrophism and neptunism also the geology and geomorphology of Indian subcontinent including time line, origin and future evolution of earth.
CO 5:	To understand about the disturbance created by different kinds in different sphere on the earth by human population, atmosphere, hydrosphere, geosphere, biosphere creating pollution and biodiversity loss.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 **The Earth and the Universe**	The Earth and the Universe: (a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. (b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's	**CSO 1.1:** To understand the theories and evidence of the origin and evolution of universe including Big Bang theory.(U) **CSO 1.2:** To explain the concept on creation of elements and earth.(U) **CSO 1.3:** To explain the holistic understanding of our dynamic planet through astronomy, geology, meteorology and oceanography. (U) **CSO 1.4:** To describe and give introduction to various branches of earth science .(K) **CSO 1.5:** To explain the general characteristics of the universe including its	14	23	Not to be filled-in

	orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. (c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background	vastness, structure and composition and origin of the universe.(U) **CSO 1.6:** To explain the structure and component of milky way galaxy, solar system, earth's orbit and spin in our universe.(U) **CSO 1.7:** To understand and explore the structure and formation ofthe moon's orbit and spin.(U) **CSO 1.8:** To understand and differentiating betweenthe terrestrial and Jovian planets.(K) **CSO 1.9:** To understand the properties and significance of meteorites and asteroids.(U) **CSO 1.10:** To explain theEarth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.(U) **CSO 1.11:**To understand and explore the various sources of energy and particles fluxes incident on the earth and effect of solar variability and space weather on earth's climate and technological infrastructure.(U) **CSO 1.12:** To explain and understand the cosmic microwave background and explore the discovery and significance also the measurement of CMB.(U)			
UNIT 2 Structure	**Structure**: (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior? (b) The Hydrosphere:	**CSO 2.1:** To understand the solid earth including its mass, dimensions, shape and topography.(U) **CSO 2.2:** To analyse internal structure of earth including composition and properties of crust, mantle and core.(A) **CSO 2.3:** To explain the earth's magnetic field and	13	23	Not to be filled-in

	The oceans, their extent, depth, volume, chemical composition. River systems. (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds. (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers. (e) The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.	geothermal energy. (U) **CSO 2.4:** To explain methods used to learn earth's interior including seismology, geodesy and laboratory experiments.(U) **CSO 2.5:** To understand the ocean as a major component of earth's hydrosphere, including their extend , depth, and volume..(U) **CSO 2.6:** To explain the chemical composition of seawater.(U) **CSO 2.7:** To explain the river system and studying their characteristics and role in the hydrological cycle.(U) **CSO 2.8:** To understand the variation of temperature, density and composition of the earth's atmosphere with altitude.(U) **CSO 2.9:** To explain the atmospheric phenomena such as clouds and circular pattern of atmosphere.(U) **CSO 2.10:** To explain the polar caps and ice sheets as major components of earth's cryosphere, including their extend, thickness and dynamics.(U) **CSO 2.11:** To understand the formation of mountain glaciers, movement and significance in shaping landscape.(U) **CSO 2.12:** To understand the role of gynosphere in global climate progress.(u) **CSO 2.13:** To understand the chemical composition and mass of earth's biosphere, including the distribution of organic matter and nutrients.(U) **CSO 2.14:** To understand			

		the diversity of plants and animals and their ecological role and study marine and terrestrial organisms including adaptation to different environments.(U)			
UNIT 3 Dynamical Processes	**Dynamical Processes**: (a) The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical Layering of the Earth. Introduction to geophysical methods of earth Investigations. Concept of plate tectonics; sea-floor spreading and continental Drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, Transform faults and island arcs. Origin of oceans, continents, mountains and Rift valleys. Earthquake and earthquake belts. Volcanoes: types products and Distribution.(b) The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis. (c) The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget.	**CSO 3.1:**To understand the origin of the earth's magnetic field, .(U) **CSO 3.2:**To explain the source of geothermal energy including heat transfer mechanism from earth's interior to the surface.(U) **CSO 3.3:**To understand the earth's core convection and production of its magnetic field and mechanical layering of the earth.(U) **CSO 3.4:**To explain the concept and introduce the geophysical methods of earth.(U) **CSO 3.5:**To understand the concept of plate tectonic including sea-floor spreading and continental drift and the geodynamical elements of earth such as mid ocean ridges, trenches, transform fault and island arc.(U) **CSO 3.6:**To explain the origin of ocean, continents, mountains and rift valleys(A) **CSO 3.7:**To understand earthquakes and earthquakes belt, including their causes, distribution and seismic hazards.(U) **CSO 3.8:**Toexplain the types production and distribution of the volcanoes .(U) **CSO 3.1:**To explain the hydrosphere and understanding the ocean circulation .(U) **CSO 3.2:**To discuss the	14	24	Not to be filled-in

	Cyclones. Climate: i. Earth's temperature and greenhouse effect. ii. Paleoclimate and recent climate changes. iii. The Indian monsoon system. (d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state	ocean current system and effect of coriolis forces and concept of eustasy trend including air-sea interaction wave erosion and beach process.(U) **CSO 3.3:**To understand tides and tsunamis causes and variation as well as generation.(U) **CSO 3.1:**To define atmosphere and explain the atmospheric circulation .(K) **CSO 3.2:** To explain the weather and climate changes and study earth's heat budget as well as cyclones formation, structure and impact.(U) **CSO 3.3:**To discuss the climate including earth's temperature and greenhouse effect, paleo climate and recent climate change and the Indian monsoon system **CSO 3.1:**To understand the biosphere exploring the water cycle, carbon cycle, nitrogen cycle, phosphorous cycle including the movement of water. (U) **CSO 3.13:** To understand the role of biochemical cycle in maintaining a steady state within the biosphere. (U)			
UNIT 4 **Evolution**	**Evolution:** Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of	**CSO 4.1:**To understand the Evolution in nature.(U) **CSO 4.2:**To explain the nature of straightgraphic records, standard time scale and introduction to concept of time in geological studies.(U) **CSO 4.3:**To discuss about the geochronological methods and application in geological studies.(U) **CSO 4.4:**To explain the history of development in concept of	13	22	Not to be filled-in

	uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent. 1. Time line of major geological and biological events. 2. Origin of life on Earth. 3. Role of the biosphere in shaping the environment. 4. Future of evolution of the Earth and solar system: Death of the Earth.	uniformitarianism, catastrophism and neptunism.(U) **CSO 4.5:**To understand the law of superposition and faunal succession.(A) **CSO 4.6:**To explain the introductory to the geology and geomorphology of Indian subcontinent.(U) **CSO 4.7:**To understand the timeline of major geological and biological events.(U) **CSO 4.8:**To understand the origin of life of earth.(U) **CSO 4.9:**To discuss the role of biosphere in shaping the environment.(U) **CSO 4.10:**To understand the future of evolution of the earth and solar system including death of the earth.(U)			
UNIT 5 Disturbing the Earth – Contemporary dilemmas	**Disturbing the Earth – Contemporary dilemmas** (a) Human population growth. (b) Atmosphere: Green house gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion. (d) Geosphere: Chemical effluents, nuclear waste. (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.	**CSO 5.1:**To understand the concept on disturbing the earth on different aspects.(U) **CSO 5.2:**To understand how the human population growth is disturbing the earth contemporary dilemmas.(U) **CSO 5.3:**To discuss the atmosphere effect including green house gas emission, climate change and air pollution.(U) **CSO 5.4:**To define and understand the hydrosphere including fresh water depletion.(K) **CSO 5.5:**To explain the geosphere including chemical effluent and nuclear waste.(U) **CSO 5.6:**To discuss about the biosphere of biodiversity loss including deforestation , robustness and fragility of ecosystem.(U)	6	8	Not to be filled-in

SUGGESTED READINGS:

1. H. Jay Melosh ,*Planetary Surface Processes*, Cambridge University Press, 2011.
2. Holme's, *Principles of Physical Geology*, Chapman & Hall, 1992.
3. Emiliani,C, *Planet Earth, Cosmology, Geology and the Evolution of Life and Environment*, Cambridge University Press, 1992.

Semester	VIII
Paper Code	PHM 10
Paper Title	Astrobiology and Extraterrestrial Life
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Astrobiology and extraterrestrial life**:

CO 1:	To make the students aware of the basic components of Astrophysics.
CO 2:	To explain to students about the history of astrobiology.
CO 3:	To create an understanding among the students on how stars and solar system are formed.
CO 4:	To inform the students about habitable planets and extraterrestrial life.
CO 5:	To assist the students in the understanding of extrasolar planets and prospects for life on Mars..

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Basic Concepts of Astrophysics**	Basic concepts - Astronomical Units, Light year, parallax, Astronomical Coordinates, Kepler's Laws, Optical telescopes and their characteristics, Modern Optical telescopes, Astronomical Instruments – Photometer, Photographic plates, Spectrographs, Charge Coupled Detector.	**CSO 1.1:**To define Astronomical units. (K) **CSO 1.2:**To describe light year. (K) **CSO 1.3:**To explain parallax. (U) **CSO 1.4:**To explain Astronomical coordinates. (U) **CSO 1.5:**To discuss Kepler's law. (U) **CSO 1.6:** to define the term convergence. (K) **CSO 1.7:**To elaborate and characterize optical telescopes. (A) **CSO 1.8:**To explain modern optical telescopes. (U) **CSO 1.9:**To describe different types of astronomical instruments such as photometer, photographic plates, spectrographs and charge coupled detector. (K)	12	20	Not to be filled-in
UNIT 2 **Astrobiology History of Astrobiology**	Astrobiology History of Astrobiology, Life on earth, structure of Life – building blocks, cells, Life on	**CSO 2.1:**To explain Astrobiology history. (U) **CSO 2.2:**To describe life on earth. (K) **CSO 2.3:**To explain structure of life	12	20	Not to be filled-in

	earth – Conditions on early earth, evidence of life, the tree of life, life in extreme environments, the rise of multicellularity, the great oxidation event.	– building blocks and cells. (U) **CSO 2.4:**To discuss the conditions on early earth. (U) **CSO 2.5:**To examine the evidence of life. (A) **CSO 2.6:**To discuss the tree of life. (U) **CSO 2.7:**To understand life in extreme environments. (U) **CSO 2.8:**To explore the rise of multicellularity. (A) **CSO 2.9:**To discuss the great oxidation event. (U)			
UNIT 3 **Star & Solar system Formation of star**	Star & Solar system Formation of star, Classification of star – HR diagram, White dwarfs, Neutron stars, Pulsars, Supernovae, Stellar Black holes, Solar system - formation of solar system, sun – characteristics & its different zones, Interior & Exterior planets – properties, satellites, Kuiper belt, Oort clouds.	**CSO 3.1:**To describe star and solar system. (K) **CSO 3.2:**To explain the formation for stars (U) **CSO 3.3:**To discuss the classification of star – HR diagram. (U) **CSO 3.4:**To describe white dwarfs. (K) **CSO 3.5:**To describe white dwarfs. (K) **CSO 3.6:**To describe neutron stars. (K) **CSO 3.7:**To describe supernovae. (K) **CSO 3.8:**To describe stellar black holes. (K) **CSO 3.9:**To explain the formation of solar system. (U) **CSO 3.10:**To characterise sun and its different zones. (A) **CSO 3.11:**To explain interior and exterior planets. (U) **CSO 12:**To list the properties of satellites, Kuiper belt and oort clouds. (K)	12	20	Not to be filled-in
UNIT 4 **Habitable planets & Extraterrestrial Intelligence Habitable planets**	Habitable planets & Extraterrestrial Intelligence Habitable planets – Characteristics &Conditions, Life on Mars – locations, Europa, Enceladus & Other Icy Bodies, Methods of detection of exoplanets, Bio-signature of life on exoplanet atmosphere, how tolook Bio-signatures, Missions to search for Bio-signatures,	**CSO 4.1:**To describe habitable planets and extraterrestrial intelligence. (K) **CSO 4.2:**To characterise habitable planets and its conditions. (A) **CSO 4.3:**To explain life on mars-locations, Europa, Enceladus and other icy bodies. (U) **CSO 4.4:**To classify the methods of detection of exoplanet atmosphere. (A) **CSO 4.5:**To discuss how to look for Bio-signatures. (U) **CSO 4.6:**To discuss the missions to search for Bio-signatures. (U) **CSO 4.7:**To discuss about contacting extraterrestrial civilization. (U) **CSO 4.8:**To examine the search of	12	20	Not to be filled-in

	Contacting Extraterrestrial civilization, the search of Extraterrestrial intelligence.	extraterrestrial intelligence. (A)			
UNIT 5 Extrasolar planets and prospects for life on Mars	**Extrasolar planets:** Discovery of planets around other stars; summary of discoveries to-date; limitations of the current methods; future imaging of extra solar terrestrial; spectroscopic search for bio signatures in the atmosphere of extrasolar planets; interstellar panspermia **Prospects for life on Mars:** Evidence for surface water in the past; climate change; Viking results; possible sub-surface life; Martian palaeontology; future exploration	**CSO 5.1:**To list the discovery of planets around other stars. (K) **CSO 5.2:**To summarize discoveries to-date. (U) **CSO 5.3:**To describe the limitations of the current methods. (K) **CSO 5.4:**To discuss future imaging of extra solar terrestrial. (U) **CSO 5.5:**To explore the spectroscopic search for bio signatures in the atmosphere of extrasolar planets. (A) **CSO 5.6:**To explain interstellar panspermia. (U) **CSO 5.7:**To discuss the evidence for surface water in the past. (U) **CSO 5.8:**To define climate change. (K) **CSO 5.9:**To explain Viking results. (U) **CSO 5.10:**To explore sub-surface life. (A) **CSO 5.11:**To explore Martian palaeontology. (A) **CSO 5.12:**To discuss future exploration. (U) **CSO 5.13:** to explain composite Simpson's rule. (U) **CSO 5.14:** to define ordinary Differential equation. (K) **CSO 5.15:** to explain Euler's method. (U) **CSO 5.16:** to explain Runge-Kutta methods of order two and four. (U) CSO 20:	12	20	Not to be filled-in

SUGGESTED READINGS:

1. BW Carroll & DA Ostlie, *An Introduction to Modern Astrophysics*, Latest Edition,AddisonWesley ,2005.
2. Martin Harwit, *Astrophysical Concepts*, Latest Edition, Springer,2014
3. C.R. Kitchin, *Astrophysical Techniques*, CRC press(2015.
4. Carroll, Bradley W., and Dale A. Ostlie. *An Introduction to Modern Astrophysics.* Reading, MA: Addison-Wesley Pub., 1995.
5. Kippenhahn, Rudolf, and Alfred Weigert. *Stellar Structure and Evolution*,New York, NY: Springer-Verlag, 1990.
6. Teerikorpi, P, *The Evolving Universe and the Origin of Life*, Springer publishing,2001.
7. Souza, Valeria, Segura, Antígona, Foster, Jamie, *Astrobiology and Basin as an Analog of Early Earth*, Springer, 19

SKILL ENHANCEMENT COURSES (SEC)

Semester-I

Semester	I
Paper Code	PHS 1
Paper Title	Renewable Energy and Energy Harvesting
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Renewable energy and energy harvesting**:

CO 1:	To make the students understand fossil fuel , nuclear energy and various renewable energy source with focus on solar energy technologies and their applications in addressing global energy challenges and transitioning to sustain energy future.
CO 2:	To understand various renewable energy harvesting technologies, including wind, ocean, geothermal, hydro and piezoelectric energy and their potential application in sustainable energy system.
CO 3:	To create an understanding of electromagnetic energy harvesting, carbon capture technologies, environmental issues related to energy production and consumption and the importance of renewable source of energy. Hands-on demonstration and experiment allowing applying theoretical knowledge to practical applications.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Fossil fuels and alternate source of Energies	**Fossil fuels and Alternate Sources of energy**: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass,	**CSO 1.1:** To understand fossil fuel and nuclear energy as traditional sources of energy including their limitation .(U) **CSO 1.2:** To explain the need of renewable energy and also the non-conventional energy source.(U) **CSO 1.3:** To explain an overview of development in offshore wind energy, tidal energy, wave energy system, ocean thermal energy conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal and tidal energy.(U) **CSO 1.4:** To understand the development in offshore wind energy, including offshore wind farm, turbine technology and	8	18	Not to be filled-in

	biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.	potential challenges and opportunities for offshore wind power generation.(U) **CSO 1.5:** To explain geothermal energy and hydroelectricity as renewable source of energy derived from natural processes.(U) **CSO 1.6:** To understand the importance of solar energy as a sustainable and abundant source of renewable energy, including its potential for reducing greenhouse gas emission and climate change.(U) **CSO 1.7:** To explain the method for the storage of solar energy, including technologies such as solar pond and non-conventional solar ponds.(U) **CSO 1.8:** To explain various application of solar energy including solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell.(U) **CSO 1.9:** To understand need and characteristics of photovoltaic system including PV models, equivalent circuit and sun tracking system.(U)			
UNIT 2 **Wind energy harvesting; ocean energy; geothermal energy; hydro energy; piezoelectric energy harvesting**	Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean	**CSO 2.1:** To understand the fundamentals of wind energy harvesting.(U) **CSO 2.2:** To explain the wind turbines and different electrical machines in wind turbines.(U) **CSO 2.3:** To explain the power electronic interface and grid interconnection topologies. (U) **CSO 2.4:** To understand the ocean energy potential compared to wind and solar energy.(U) **CSO 2.5:** To analyse wave characteristics and statistics to understand the variability and predictability of wave energy source and wave energy device.(A) **CSO 2.6:** To understand the tide characteristics and statistics, tide energy technologies.(U) **CSO 2.7:** To understand ocean thermal energy, osmotic power and ocean biomass for potential energy	10	20	Not to be filled-in

	Thermal Energy, Osmotic Power, Ocean Bio-mass. Geothermal Energy: Geothermal Resources, Geothermal Technologies. Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power	harvesting applications.(U) **CSO 2.8:** To explain the geothermal resources and understand the geological processes that produce heat within earth's crust and exploring geothermal technologies.(U) **CSO 2.9:** To understand hydropower resources, hydropower technologies including environmental impact of hydro power sources.(U) **CSO 2.10:** To understand the concept of piezoelectric energy harvesting and understand the physics and characteristics of the piezoelectric effect.(U) **CSO 2.11:** To discuss the materials used in piezoelectric energy harvesting devices and mathematical description of piezoelectric.(A) **CSO 2.12:** To understand piezoelectric parameters and modelling for energy harvesting applications including vibration energy harvesting and human powered devices.(U)			
UNIT 3 **Electromagnetic energy harvesting; cell,batteries and power consumption; environmental issue and renewable sources of energy; demonstration and experiments**	Electromagnetic Energy Harvesting Linear generators, physics mathematical models, recent applications. Carbon captured technologies, cell, batteries, power consumption. Environmental issues and Renewable sources of energy, sustainability. Demonstrations and Experiments: Demonstration of Training modules on Solar energy, wind energy, etc.	**CSO 3.1:**To understand the concept of electromagnetic energy harvesting, particularly focusing on linear generator.(U) **CSO 3.2:**To explain the physics and mathematical models and study recent application of electromagnetic energy harvesting .(U) **CSO 3.3:**To discuss about carbon captured technologies, cell, batteries, and understanding power consumption in various device and system.(U) **CSO 3.4:**To explain environmental issue with conventional energy source.(U) **CSO 3.5:**To understand importance of adopting renewable energy	9	20	Not to be filled-in

	Conversion of vibration to voltage using piezoelectric materials. Conversion of thermal energy into voltage using thermoelectric modules	technologies to address environmental challenges and achieve sustainable development goals.(U) **CSO 3.6:**To demonstrate training modules on solar energy, wind energy and other renewable energy technologies to provide hands-on experience and practical understanding of energy harvesting principles.(A) **CSO 3.7:**To demonstrate the experimental conversion of vibration to voltage using piezoelectric material and the conversion of thermal energy to voltage using thermoelectric modules.(A)			

SUGGESTED READINGS:

1. G.D Rai, *Non conventional energy sources* , Khanna Publishers, New Delhi.
2. M P Agarwal ,*Solar energy* , S Chand and Co. Ltd.
3. Suhas P Sukhative ,*Solar energy* ,Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, *Renewable Energy, Power for a sustainable future*, Oxford University Press, in association with The Open University, 2004.
5. Dr. P Jayakumar, *Solar Energy*: Resource Assesment Handbook, 2009.

Semester-II

Semester	II
Paper Code	PHS 2
Paper Title	Basic Instrumentation Skills
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Basic instrumentation skills**:

CO 1:	To make the students understand both theoretical principles and practical aspects of basic measurements instruments of electronic voltmeter, ac milli voltmeter providing a comprehensive understanding of their operation, specification and significance in various measurement.
CO 2:	To understand cathode ray oscilloscope through block diagram, construction and explanation and giving specification of CRO, also understanding the signal generator, use and analysing the instruments.
CO 3:	To create an understanding among the students, in impedance bridge and Q-meters including block diagram and specification; understanding the working principles and characteristics of digital instruments as well as digital multimeter in various measurement

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Basic of measurement; Electronic voltmeter; AC millivoltmeter**	**Basic of Measurement**: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multi-meter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multi-meter and their significance.	**CSO 1.1:** To describe instruments accuracy, precision, sensitivity, resolution range etc. (K) **CSO 1.2:** To analyse errors in measurements and loading effects. (A) **CSO 1.3:** To explain multi-meter including principles of measurement of dc voltage and dc current, ac voltage, ac current an resistance. (U) **CSO 1.4:** To explain the specifications of a multi-meter. (U) **CSO 1.5:** To understand the electronic voltmeters advantage over conventional multi-meter for voltage measurement with respect to input impedance and sensitivity. (U) **CSO 1.6:** To discuss the principles of voltage measurement (block diagram only). (U) **CSO 1.7:** To discuss the specification of an electronic voltmeter and their	8	17	Not to be filled-in

	Electronic Voltmeter: Advantage over conventional multi-meter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter Multi-meter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters Amplifier- rectifier, and rectifier-amplifier. Block diagram ac millivoltmeters specifications and their significance	significance. (U) **CSO 1.8:** To explain types of AC millivoltmeter including amplifier-rectifier and rectifier-amplifier.(U) **CSO 1.9:** To explain block diagram ac millivoltmeters. (U) **CSO 1.10:** To write the specification and the signification block diagram ac millivoltmeter. (K)			
UNIT 2 **Cathode ray oscilloscope; Specifications of a CRO and their significance; Signal generator and analysis instrument**	**Cathode Ray Oscilloscope**: Block diagram of basic CRO. Construction of CRT. Electron gun, electrostatic focusing and acceleration (Explanation only-no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls **Specifications of a CRO and their significance.**	**CSO 2.1:** To illustrate block diagram of basic CRO. (U) **CSO 2.2:** To explain the construction of CRT including electron gun, electrostatic focusing and acceleration (explanation only-on mathematical treatment). (U) **CSO 2.3:** To write brief discussion on screen phosphor, visual persistence and chemical composition. (K) **CSO 2.4:** To explain time base operation, synchronization including front panel controls. (U) **CSO 2.5:** To explain specification of a CRO and their significance. (U) **CSO 2.6:** To understand the use of CRO for the measurement of voltage (dc and ac) including frequency and time period. (U) **CSO 2.7:** To explain special feature of dual trace. (U) **CSO 2.8:**To explain the introductory in digital oscilloscope and probs. (U) **CSO 2.9:** To explain digital storage oscilloscope using block diagram and working principles. (U)	13	20	Not to be filled-in

	Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **Signal Generators and Analysis Instruments**: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.	**CSO 2.10:** To write block diagram on signal generator and analysis instruments including explaination and specification of low frequency signal generators, pulse generator and function generator. (A) **CSO 2.11:** To explain brief idea for testing and specification including distortion factor meter and wave analysis. (U)			
UNIT 3 Impedance Bridge and Q-meters; Digital instruments; Digital multimeter	**Impedance Bridge & Q-Meters:** Block diagram of bridge. Working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q-Meter, Digital LCR bridges. **Digital Instruments**: Principle and working of digital meters, Comparison of analog& digital instruments, Characteristics of a digital meter. Working principles of digital voltmeter.	**CSO 3.1:** To explain impedance bridge and Q-meters from block diagram of bridge. (U) **CSO 3.2:** To explain working principles of basic RLC bridge including specification. (U) **CSO 3.3:** To understand block diagram and working principles of Q-meter. (U) **CSO 3.4:** To explain digital LCR bridges. (U) **CSO 3.5:** To understand digital instruments through principle and working of digital meters. (U) **CSO 3.6:** To write the comparison of analog and digital instrument. (K) **CSO 3.7:** To explain the characteristics of a digital meter including working principles of digital voltmeter. (U) **CSO 3.8:** To explain digital multimeter from block diagram and working of a digital multimeter. (U) **CSO 3.9:** To explain the working principle of time interval, frequency and period measurement using	7	13	Not to be filled-in

	Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter frequency counter, time- base stability, accuracy and resolution.	universal counter frequency counter. (U) **CSO 3.10:** To understand time-based stability accuracy and resolution. (U)			

SUGGESTED READINGS:

1. A.P. Malvino, D.P.Leach and Saha, *Digital Principles and Applications*, 7 Ed. , Tata Mc Graw , 2011.
2. Anand Kumar, *Fundamentals of Digital Circuits*, 2ndEdn, PHI Learning Pvt. Ltd ,2009.
3. Venugopal, *Digital Circuits and systems*, Tata McGraw Hill ,2011.
4. G K Kharate ,*Digital Electronics*, Oxford University Press , 2010.
5. R.J.Tocci, N.S.Widmer, *Digital Systems: Principles & Applications*, PHI Learning ,2001.
6. S.K. Mandal, *Digital Electronics*, 1st edition, McGraw Hill , 2010.
7. S.Salivahanan&N.S.Kumar, *Electronic Devices & circuits*, 3rd Ed., PHI Learning ,Tata Mc-Graw Hill,2012.

Semester-III

Semester	III
Paper Code	PHS 3
Paper Title	Radiation Safety
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Radiation Safety**:

CO 1:	To create an awareness among the students about Basics of Atomic and Nuclear Physics and Interaction of Radiation with matter.
CO 2:	To instill the idea of Radiation detection and monitoring devices.
CO 3:	To let the students understand the concepts Radiation safety management and Application of nuclear techniques.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 **Basics of Atomic and Nuclear Physics and Interaction of Radiation with matter**	Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half-life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction,Fusion,fission. **Interaction of Radiation with matter:** **Types of Radiation:** Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons-** Photo- electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients **Interaction of Charged Particles:** Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung),	**CSO 1.1:** To explain about the basic concept of atomic structure. (K+U) **CSO 1.2:** To define X-ray (K) **CSO 1.3:** To illustrate on X-ray Characteristic and its production (A) **CSO 1.4:** To define and explain on concept of bremsstrahlung and auger electron (K+U) **CSO 1.5:** To define nucleus and explain on the composition of nucleus and its various properties (K+U) **CSO 1.6:** To define and explain mass number, isotopes, spin, and binding energy of the nucleus (K+U+A) **CSO 1.7:** To define and compare the difference between stable and unstable nucleus (K+U+A) **CSO 1.8:** To define and derive the law of radioactive decay (K+A) **CSO 1.9:** To define and discussmean life, half life (K+U) **CSO1.10:** To define and explain on basic concept of alpha, beta and gamma decay**(**K+U+A**)** **CSO1.11:** To define and explain on concept of cross section and kinematics of nuclear reactions **CSO 1.12:** To define nuclear reaction and discuss on its various types (K+U+A) **CSO 1.13:** To discuss on the interaction of photons by studying photoelectric effect and Compton scattering ,etc. (U+A) **CSO 1.14**: To discuss and	14	17	Not to be filled-in

		explain on the interaction of charged particles by using the methods mentioned(U+A)			
UNIT 2 Radiation detection and monitoring devices	Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). **Radiation detection:** Basic concept and working principle of gas detectors (Ionization Chamber, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors **(**Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.	**CSO 2.1:** To explain about the basic idea of different units used in radiation detection and monitoring devices. (K+U) **CSO 2.2:**To define KERMA and to explain about parameter related to KERMA. (K+U) **CSO 2.3:**To illustrate on the parameter like exposure, absorbed dose, equivalent dose, effective dose and equivalent dose as radiation quantities (U+A) To define **CSO 2.4:**To define and compare between Annual Limit of Intake and Derive Air Concentration (A+U) **CSO 2.5:** To define detectors and explain on the basic concept and principle of gas detectors (K+U) **CSO 2.7:**To explain and illustrate on the use of various types of detectors mentioned in radiology. (K+U+A)	6	13	Not to be filled-in
UNIT 3 **Radiation safety management and Application of nuclear techniques**	Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. **Application of nuclear techniques:** Application in	**CSO 3.1:**To define radiation safety (K) **CSO 3.2:**To illustrate on the Biological effects of ionizing radiation safety management (U+A*)* **CSO 3.3:**To discuss on the operational limits and basic idea on radiation hazard evaluation control (U) **CSO 3.4:**To Add on the radiation hazards evaluation and control by supplementing it with ICRP Principles (U+A)	10	20	Not to be filled-in

	medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.	**CSO 3.5:**To discuss on the risk and safety in management of radiation and ways to dispose nuclear waste (K+U+A) **CSO 3.6:**To discuss on the use of nuclear technique in modern medical science by taking examples like MRI,PET, etc. (U+A) **CSO 3.7:**To discuss and illustrate its use in archaeology, Art, mining industries, etc. (U+A)			

SUGGESTED READINGS:

1. W.E.Burcham and M.Jobes,*Nuclear and Particle Physics*,Longman, 1995.
2. Dosimetry,Mcknlay,A.F.,Bristol,Adam Hilger, *Thermo luminescence (Medical Physics Handbook 5).*
3. W.J.Meredith and J.B.Massey,*Fundamental Physics of Radiology*, John Wright and Sons, UK, 1989.
4. J.R.Greening, *Fundamentals of Radiation Dosimetry,Medical Physics Hand Book Series, No.6*, Adam Hilger Ltd., Bristol 1981.
5. G.C.Lowental and P.L. Airey,*Practical Applications of Radioactivity and Nuclear Radiations*, Cambridge University Press, U.K., 2001.
6. A.Martin and S.A.Harbisor,*An Introduction to Radiation Protection*,John Willey & Sons, Inc. New York, 1981.
7. W.R.Hendee,*Medical Radiation Physics*,Year Book–Medical Publishers Inc. London, 1981.

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Semester-IV

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Semester	IV
Paper Code	PHS 4
Paper Title	Electrical Circuit and Network
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Electrical circuits and network**:

CO 1:	To introduce to students' basic electricity principles and make them understand electrical circuits.
CO 2:	To make the students learn about electrical drawing and symbols, generators, transformers and electric motors.
CO 3:	To aid the students in understanding solid states devices and aware of electrical protection as well as electrical wiring.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Basic Electricity Principles and understanding electrical circuits	**Basic Electricity Principles**: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **Understanding Electrical Circuits:** Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase	**CSO 1.1:**To describe voltage (K) **CSO 1.2:** To describe Current. (K) **CSO 1.3:**To describe resistance. (K) **CSO 1.4:**To describe power. (K) **CSO 1.5:**To explain Ohm's law. (U) **CSO 1.6:**To explain in detail about series combination. (U) **CSO 1.7:**To explain in detail about parallel combination. (U) **CSO 1.8:**To explain in detail about series-parallel combination. (U) **CSO 1.9:**To distinguish AC and DC electricity. (A) **CSO 1.10:**To characterize multimeter,	7	14	Not to be filled-in

	alternating current sources. Rules to analyse AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.	voltmeter and ammeter. (A) **CSO 1.11:**To discuss the main electric circuits and their combination. (U) **CSO 1.12:** To explain the rules required to analyse DC sourced electrical circuits. (U) **CSO 1.13:** To examine the current and voltage drop across the dc circuit elements. (A) **CSO 1.14:** To distinguish single phase and three phase alternating current sources. (A) **CSO 1.15:** To explain the rules required to analyse AC sourced electrical circuits. (U) **CSO 1.16:** To distinguish real, imaginary and complex power components of AC source. (A) **CSO 1.17:** To describe power factor. (K) **CSO 1.18:** To write about saving energy and money. (K)			
UNIT 2 Electrical Drawing and Symbols, Generators, Transformers and electric motors.	**Electrical Drawing and Symbols:** Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **Generators and Transformers:** DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **Electric Motors:** Single-phase, three-	**CSO 2.1:**To explain drawing symbols. (U) **CSO 2.2:**To describeBlueprints. (U) **CSO 2.3:**To enumerate reading schematics. (K) **CSO 2.4:**To explain reading ladder diagrams. (U) **CSO 2.5:**To enumerate electrical schematics. (K) **CSO 2.6:**To describe power circuits. (K) **CSO 2.7:**To describe Control circuits. (K) **CSO 2.8:**To describe reading a circuit schematic. (K) **CSO 2.9:**To identify how to track connections of elements and identify current flow and voltage drop. (K) **CSO 2.10:**To describe DC power sources. (K)	10	17	Not to be filled-in

	phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.	**CSO 2.11:**To explain AC/DC generators. (U) **CSO 2.12:** To define and describe inductance, capacitance and impedance. (K) **CSO 2.13:** To discuss operation of transformers. (U) **CSO 2.14:** To explain single-phase, three phase and DC motors. (U) **CSO 2.15:** To examine interfacing DC or AC sources to control heaters and motors. (A) **CSO 2.16:** To explain speed and power of ac motor. (U)			
UNIT 3 **Solid State Devices, electrical protection and electrical wiring**	**Solid State Devices:** resistors, inductors and capacitors. Diode and rectifiers Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. **Electrical protection:** Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device) . **Electrical Wiring:** Different types of conductors and cables. Basics of Wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and	**CSO 3.1:**To describe resistors, inductors and capacitors. (K) **CSO 3.2:**To explain diode and rectifiers. (U) **CSO 3.3:**To describe the components in series and shunt. (K) **CSO 3.4:**To examine the response of inductors and capacitors with DC or AC sources. (A) **CSO 3.5:**To describe relays. (K) **CSO 3.6:**To describe fuses and disconnect switches. (K) **CSO 3.7:**To explain circuit breakers. (U) **CSO 3.8:**To discuss overload devices. (U) **CSO 3.9:**To examine ground fault protection. (A) **CSO 3.10:**To describe grounding and isolating. (K) **CSO 3.11:** To understand phase reversal. (U) **CSO 12:**To explain surge protection. (U) **CSO 3.13:**To examine interfacing DC or AC sources to control elements. **CSO 3.14:** To distinguish different types of	13	19	Not to be filled-in

	stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.	conductors and cables. (A) **CSO 3.15:** To explain basics of wiring-star and delta connection. (U) **CSO 3.16:** To discuss voltage drop and losses across cables and conductors. (U) **CSO 3.17:** To list the instruments to measure current, voltage, power in DC and AC circuits. (K) **CSO 3.18:** To identify insulation, solid and stranded cables, conduit, cable trays, splices-wirenuts, crimps, terminal blocks, split bolts and solder. (A) **CSO 3.19:** To discuss preparation of extension board. (U)			

SUGGESTED READINGS:

1. B L Theraja , A K Theraja , *A text book in Electrical Technology* , S Chand & Co. 23rd Edn,1959.
2. M G Say ,*Performance and design of AC machines* , ELBS Edn.

Semester-V

Semester	V
Paper Code	PHS 5
Paper Title	Basic Workshop Skills
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Basic Workshop Skills**:

CO 1:	To make the students understand the Introduction to different instruments and mechanical skill 1.
CO 2:	To make the students understand mechanical skill 2 i.e introducing them to common machine tools.
CO 3:	To introduce the students to electrical and electronic Skill.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to different instruments and mechanical skill 1	**Introduction:** Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet etc. Use of Sextant to measure height of buildings, mountains, etc. **Mechanical Skill 1**: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood.	**CSO 1.1:** To learn the measuring units.(K) **CSO 1.2:** To define SI and CGS units and learn their conversion.(K) **CSO 1.3:** To define meter scale, Vernier calliper, Screw gauge and learn their utility.(K&A) **CSO 1.4:** To learn to measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet using the different instruments. (A) **CSO 1.5:** To define sextant.(K) **CSO 1.6:** To learn to use sextant to measure height of buildings, mountains etc.(U) **CSO 1.7:** To understand the concept of workshop practice. (U) **CSO 1.8:** To learn the overview of manufacturing methods like casting, foundry, machining, forming and welding.(U) **CSO 1.9:** To explain the types of welding joints and welding defects.(U) **CSO 1.10:** To classify the common materials used for manufacturing. (U)	8	17	Not to be filled-in
UNIT 2 Mechanical Skill 2	Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.	**CSO 2.1:** To explain the concept of machine processing. (U)) **CSO 2.2:** To define lathe, shaper, drilling, milling, surface machines.(K) **CSO 2.3:** To learn cutting tools and lubricating oils.(U) **CSO 2.4:** To learn the concept of cutting a metal sheet using blade.(U) **CSO 2.5:** To explain smoothening of cutting edge of sheet using file.(U) **CSO 2.6:** To explain drilling of holes of different diameter in metal sheet and wooden block. (U) **CSO 2.7:** To explain the use of bench vice and tools for fitting.(U) **CSO 2.8:** To make funnel using metal sheet.(A)	6	13	Not to be filled-in
UNIT 3 Electrical and Electronic Skill	Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope.	**CSO 3.1:** To define multimeter.(K) **CSO 3.2:** To learn the use of multimeter.(A) **CSO 3.3:** To explain the soldering of electrical circuits having discrete components.(A)	16	20	Not to be filled-in

	Making regulated power supply. Timer circuit, Electronic switch using transistor and relay. **Introduction to prime movers**: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever, braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.	**CSO 3.4:** To explain the operation of an oscilloscope.(U) **CSO 3.5:** To explain how to make regulated power supply.(A) **CSO 3.6:** To explain timer circuit, electronic switch using transistor and relay.(U) **CSO 3.7:** To introduce prime movers.(K) **CSO 3.8:** To introduce the mechanism.(K) **CSO 3.9:** To explain the gear system and wheel.(U) **CSO 3.10:** To explain the fixing of gears with motor axel.(U) **CSO 3.11:** To explain the mechanism of a lever.(U) **CSO 3.12:** To explain lifting of heavy weight using lever.(U) **CSO 3.14:** To explain the mechanism of braking systems, pilleys.(U) **CSO 3.15:** To explain the working principles of power generation systems. (U) **CSO 3.16:** To show the demonstration of pulley experiment.(A)			

SUGGESTED READINGS:

1. B LTheraja ,A *textbook in Electrical Technology*,S.Chand and Company, 23rd Edn,1959.
2. M.G.Say ,*Performance and design of AC machines*,ELBSEdn.
3. K.C.John, *Mechanical workshop practice* ,PHI LearningPvt.Ltd. 2010.
4. Bruce J Black,*Workshop Processes,Practices and Materials,* 3rdEdn., Editor Newnes, 2005 [ISBN: 0750660732]

Semester	V
Paper Code	PHS 6
Paper Title	Weather Forecasting
Number of teaching hours per week	02
Total number of teaching hours per semester	30
Number of credits	02

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Weather forecasting**:

CO 1:	To make the students understand the atmosphere and the process involved in measuring weather variables such as temperature, pressure, wind, humidity, clouds, rainfall and radiation also introducing fundamental weather phenomena and atmospheric dynamics.
CO 2:	To understand weather system, climate processes and the drivers and impact of climate change also addressing the interconnections of atmospheric dynamics, environmental factors and societal response to climate related challenges.
CO 3:	To provide a foundational understanding to weather forecasting principles, method and

	technique as well as the challenges and the uncertainties associate with predicting future weather condition and importance of weather forecasting.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to atmosphere, Measuring the weather	**Introduction to atmosphere:** Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. **Measuring the weather:** Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.	**CSO 1.1:** To understand the elementary idea of the atmosphere including its physical structure and composition.(U) **CSO 1.2:** To explain the concept of compositional layering of the atmosphere.(U) **CSO 1.3:** To explain the variation of pressure and temperature with height. (U) **CSO 1.4:** To describe about the air temperature including the requirement to measure air temperature and types of temperature sensor.(K) **CSO 1.5:** To understand the atmospheric pressure and its measurement and characteristics including cyclones and anticyclones.(U) **CSO 1.6:** To understand about the measuring of the weather .(U) **CSO 1.7:** To explain wind including forces acting to produce wind, its speed direction including units of measurement.(U) **CSO 1.8:** To explain the humidity, clouds and rainfall.(K) **CSO 1.9:** To understand the concept of radiation in the atmosphere including absorption, emission and scattering also the law of radiation in the atmosphere.(U)	13	20	Not to be filled-in
UNIT II Weather systems,Climate and Climate Change	**Weather systems:** Global wind systems; air masses and fronts: classifications; jet streams; local	**CSO 2.1:** To understand the weather system by exploring in different fields.(U) **CSO 2.2:** To understand	9	15	Not to be filled-in

	thunderstorms; tropical cyclones: classification; tornadoes; hurricanes. **Climate and Climate Change:** Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.	the global wind system including air masses and front classification and their influence.(U) **CSO 2.3:** To explain the concept of jet streams including their classification and their influence on weather pattern and aviation. (U) **CSO 2.4:** To understand the local thunderstorm formation, characteristics.(U) **CSO 2.5:** To understand the cyclones their classifications including tornadoes and hurricanes and their impact on the coastal region and societies.(U) **CSO 2.6:** To understand the climate and climate change and its classification including causes of climate change.(U) **CSO 2.7:** To explain the global warming and its outcomes(U) **CSO 2.8:** To understand the air pollution and its contribution to climate change including role of aerosols.(U) **CSO 2.9:** To explain the ozone depletion, acid rain and environmental issue relating to climate change.(U)			
UNIT III Basics of weather forecasting	**Basics of weather forecasting:** Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps;	**CSO 3.1:**To understand the basic concept of weather forecasting.(U) **CSO 3.2:**To explain the weather forecasting analysis and its historical background.(A) **CSO 3.3:**To understand the need of measuring weather variable and their importance .(U) **CSO 3.4:**To explain the different types of weather forecasting and weather forecasting method.(U) **CSO 3.5:**To understand	8	15	Not to be filled-in

	uncertainty and predictability; probability forecasts.	the criteria of choosing weather station including basics of choosing site and exposure.(U) **CSO 3.6:**To explain the important role of satellites observation in weather forecasting.(A) **CSO 3.7:**To understand the weather map including uncertainty and predictability and giving the probability forecasts.(U)			

<u>SUGGESTED READINGS</u>:

1. I.C. Joshi, *Aviation Meteorology*,Himalayan Books,3rd edition ,2014.
2. Stephen Burt, The *weather Observers Hand book*, Cambridge University Press,2012.
3. S.R. Ghadekar, *Meteorology*, Agromet Publishers, Nagpur ,2001.
4. S.R. Ghadekar ,*Text Book of Agrometeorology*, , Agromet Publishers, Nagpur ,2005.
5. Charls Franklin Brooks, *Why the weather*, Chpraman& Hall, London, 1924.
6. John G. Harvey, *Atmosphere and Ocean*, The Artemis Pres, 1999.