M.Sc. PHYSICS
(Effective from the academic year 2024 - 2025)

Vision of the Department:

To empower the young women by imparting quality education in physics that promotes interest and thirst for research in the field of physics to create competency and skills.

Mission:

To provide quality education through well designed programs in various areas of physics, promoting competitive physicist.

Eligibility for admission to M.Sc. Physics:

A candidate who has passed the B.Sc. Degree Examination with a score of 50% and above in physics shall be eligible for admission to M.Sc. Degree Programme in Physics.

Objectives:

- To equip the knowledge and the skills needed to understand, improve and preserve the physical environment.
- To inculcate in them the scientific temper and spirit of inventiveness.
- To identify the student's talents and traits carefully and to provide adequate expression of their personalities.
- To develop in the minds of the students a wide range of wholesome interests by providing opportunities for learning through co-operative work.

Highlights of the Revamped Curriculum:

➢ Student-centric, meeting the demands of industry & society, incorporating industrial components, hands-on training, skill development modules, industrial project, project with viva-voce, exposure to entrepreneurial skills, training for competitive examinations, sustaining the quality of the core components and incorporating application-oriented content wherever required.

➢ The Core subjects include latest developments in the education and scientific front, practical training, catering to the needs of stakeholders with research aptitude.

➢ The curriculum is designed to strengthen the industry-academia interface and provide more job opportunities for the students.

➢ The Internship during the third semester will help the students gain valuable work experience, that connects classroom knowledge to real world experience and to narrow down and focus on the career path.

➢ State-of Art techniques from the streams of multi-disciplinary, cross disciplinary and inter disciplinary nature are incorporated as Elective and Skill enhancement courses, covering conventional topics to the application oriented.

➢ Human rights course allows individual in being a responsible citizen that remains as a requisite to the possibility of a just society.

➢ MOOC course is prescribed to reinforce self-learning and to instill the value of life-long learning in students.

➢ Project with viva-voce component in the fourth semester enables the students to apply their conceptual knowledge to practical situations which will help to improve healthcare, nutrition and the environment.

Value additions in the Revamped Curriculum:

Semester	Newly introduced Components	Outcome / Benefits
I, II, III, IV	**Core Courses in Physics**	Students from Physics Major in Undergraduate get a stronger footing in the subject.
I, II, III, IV	**Elective papers -** An open choice of topics categorized under Generic and Discipline Centric	Strengthening the domain knowledge Introducing the stakeholders to the state-of art techniques from the streams of multi-disciplinary, cross disciplinary and inter disciplinary nature. Emerging topics related to industry are introduced to facilitate advanced learning in the respective domains.
II, III, IV	**Skill Enhancement papers/ Professional competency skills** (Discipline centric/ Generic / Entrepreneurial)	Industry ready graduates Skilled human resource Students are equipped with essential skills to make them employable. Entrepreneurial skill training will provide an opportunity for independent livelihood generates small scale entrepreneurs. Discipline centric skill will improve the technical knowhow of solving real life problems.
Semester III (Vacation activity)	Internship / Industrial Training	Practical training at the Industry/ Physics research concerns / Educational institutions, enable the students gain professional experience and become responsible citizens.
Semester IV	Project with Viva - voce	Self-learning, critical thinking, problem-solving and research acumen is enhanced.

Skills acquired from the Courses	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

TANSCHE BASED PROGRAMME STRUCTURE FOR M.Sc. PHYSICS

(For the candidates admitted from the academic year 2024-2025)

Sem	Part	Category	Paper Code	Title	Hours/ Week	Exam		Credits	Marks
						Th	Pr		
I	A	Core I	PCPHA24	Mathematical Physics	5	3	-	4	40+60
		Core II	PCPHB24	Classical Mechanics and Relativity	5	3	-	4	40+60
		Core III	PCPHC24	Linear and Digital ICs and Applications	5	3	-	4	40+60
		Core IV	PCPHD24	Practical I – Analog and Digital IC's and Applications	6	-	4	4	40+60
		Elective IA (Discipline Centric)	PEPHA24	Elective: Crystal Growth and Thin films	3	3	-	2	40+60
		Elective IB (Discipline Centric)	PEPHB24	Elective: Astrophysics					
		Elective IIA (Generic)	PEPHC24	Elective: Advanced Optics	3	3	-	2	40+60
		Elective IIB (Generic)	PEPHD24	Elective: Bio Physics					
	B			Human Rights	1	-	-	-	-
				Value Education	1	-	-	-	-
				Total	**30**			**20**	**600**
II	A	Core V	PCPHE24	Statistical Mechanics	5	3	-	4	40+60
		Core VI	PCPHF24	Quantum Mechanics –I	5	3	-	4	40+60
		Core VII	PCPHG24	Electromagnetic Theory	5	3	-	4	40+60
		Core VIII	PCPHH24	Practical II – General Experiments	4	-	4	4	40+60
		Elective IIIA (Discipline Centric)	PEPHE24	Elective: Advanced Mathematical Physics	3	3	-	2	40+60
		Elective IIIB (Discipline Centric)	PEPHF24	Elective: General Relativity and Cosmology					
		Elective IVA (Generic)	PEPHG24	Elective: Characterization of materials	3	3	-	2	40+60
		Elective IVB (Generic)	PEPHH24	Elective: Advanced Spectroscopy					
	B	SEC-I	PSPH124	SEC: Solar Energy Utilization	3	3		2	40+60
			PNHRA24	Human Rights	1	2	-	2	40+60
			POPH24	Online Course	-	-	-	1	-
				Value Education	1	-	-	-	-
				Total	**30**			**25**	**800**

III	A	Core IX	PCPHI24	Quantum Mechanics –II	6	3	-	5	40+60
		Core X	PCPHJ24	Condensed Matter Physics	6	3	-	5	40+60
		Core XI	PCPHK24	Numerical Methods and Computer Programming	5	3	-	5	40+60
		Core XII	PCPHL24	Practical III – Advanced Experiments	6	-	4	4	40+60
		Elective VA (Discipline Centric)	PEPHI24	Elective: Physics of Nano Science and Technology	3	3	-	3	40+60
		Elective VB (Discipline Centric)	PEPHJ24	Elective: Energy Physics					
	B	SEC- II	PSPH224	Communication Electronics	3	3	-	2	40+60
			PIPH24	Internship	-	-	-	2	100
				Value Education	1	-	-	-	-
				Total	**30**			**26**	**700**
IV	A	Core XIII	PCPHM24	Spectroscopy	5	3	-	4	40+60
		Core XIV	PCPHN24	Nuclear and Particle Physics	5	3	-	4	40+60
		Core XV	PCPHO24	Practical IV - Numerical Methods and Computer Programming (FORTRAN/C)	4	-	4	3	40+60
		Project	PCPHP24	Project	10	-	-	7	40+60
		Elective VIA	PEPHK24	Elective: Microprocessor 8085 and Microcontroller 8051	3	3	-	2	40+60
		Elective VIB	PEPHL24	Elective: Medical Physics					
	B	Professional Competency Skill	PPPH24	Solid Waste Management	2	-	-	2	100
		VE		Value Education	1	-	-	-	-
	C		PXTEN24	Extension Activity	-	-	-	1	-
				Total	**30**			**24**	**600**
				Grand Total	**120**			**94**	**2700**

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- Any one course of the following to be completed during III semester (15 hours teaching and 15 hours activities):
  i)   Teaching and Research Aptitude
  ii)   Artificial Intelligence Tools
  iii)   Entrepreneur Skill
  iv)   Photography

		Methods of Evaluation				
S. No.	Category	Assessment Tool	Maximum Marks	Exam Theory	Weightage	Marks
1	Core Courses/Generic & Discipline Specific Electives	I Continuous Assessment (ICA)	50	1 ½ h	35	40
		II Continuous Assessment (IICA)	50	1 ½ h		
		Innovative Component (IC)	5	-	5	
		End Semester Examination	100	3 h		60
2	Professional Competency	I Continuous Assessment (ICA)	30	1 h	35	40
		II Continuous Assessment (IICA)	30	1 h		
		Innovative Component (IC)	5	-	5	
		End Semester Examination	60	2 h		60
3	HR	Continuous Assessment (IICA)	25	1 h		40
		Innovative Component (IC)	25	-		
		End Semester Examination	60	2 h		60

Activity-based Assessment for Skill Enhancement Courses:

- Activity 1 for Unit I: (Nature of Activity)   – 20 marks
- Activity 2 for Unit II: (Nature of Activity)   – 20 marks
- Activity 3 for Unit III: (Nature of Activity)   – 20 marks
- Activity 4 for Unit IV: (Nature of Activity)   – 20 marks
- Activity 5 for Unit V: (Nature of Activity)   – 20 marks

Nature of Activity – Field visit/Industrial visit/Project (individual or group)/Exhibits/Model making/Hands on training/Lab practice/Product making/Extempore/Block and Tackle/Debate/Report writing/Case study/Interpretation of data or results/Transcription/Quiz (LMS)/Problem solving/ Designing/Role play/Start-up proposal/Research proposal/Poster presentation/Oral presentation (live or video recorded) / Survey (Field or Online) / Group discussion / Problem solving / Problem formulation/Interviews/Concept mapping/Mind mapping /Promoting public awareness etc.

Record of Assessment will be maintained by the course instructors and verified by the Head of the department.

Taxonomy Levels of Assessment	
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, short summary or Overview
Application (K3)	Suggest idea/concept with examples, suggest formulae, Solve problems, Observe, Explain
Analyze (K4)	Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

PROGRAMME OUTCOMES (PO)

Programme Outcomes (PO)
On completion of the PG Programme, students will be able to:

PO1: Attain an in-depth knowledge in the respective domains augmented through self-learning.
PO2: Assimilate and apply principles and concepts towards skill development and employability.
PO3: Apply critical and scientific approaches to address problems and find solutions.
PO4: Develop research skills through multi/inter/trans-disciplinary perspectives.
PO5: Integrate issues of social relevance in the field of study.
PO6: Persist in life-long learning for personal and societal progress.

Programme Specific Outcomes (PSO):
On completion of the PG Programme in Physics, students will be able to;

PSO1: Attain in depth knowledge on various areas of Physics.
PSO2: Understand the various methods in the respective field.
PSO3: Inculcate the mathematical concepts for solving problems.
PSO4: Gain knowledge about various applications.
PSO5: Become Skilled to face competitive examinations.
PSO6: Attain interest for higher education and research.

PSO/PO	PO					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
PSO1	H	H	M	H	H	M
PSO2	H	H	M	H	H	H
PSO3	H	H	M	H	H	H
PSO4	H	H	M	H	H	H
PSO5	H	H	H	H	H	M
PSO6	H	H	H	H	M	H

(HIGH - 3, MODERATE - 2, LOW - 1)

Title of the Course	MATHEMATICAL PHYSICS						
Paper No.	Core I						
Category	Core	Year	I	Credits	4	Course Code	PCPHA24
		Semester	I				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	Knowledge of Matrices, vectors, differentiation, integration, differential equations						
Objectives of the course	➢ To equip students with the mathematical techniques needed for understanding theoretical treatment in different courses taught in their program ➢ To extend their manipulative skills to apply mathematical techniques in their fields ➢ To help students apply Mathematics in solving problems of Physics						

Course Outline	**UNIT I (18hours) (K1, K2, K3, K4 & K5)**
	VECTOR ANALYSIS AND LINEAR VECTOR SPACE
	    1.1 Vector Field - Orthogonal curvilinear co-ordinates – Expression for gradient, divergence, curl and Laplacian
	    1.2 Spherical and cylindrical coordinate systems – expression for gradient, divergence, curl and Laplacian
	    1.3 Stoke's theorem – Simple applications
	    1.4 Gauss theorem - Simple applications
	    1.5 Linear vector Space – Linear independence of vectors - Basis and Expansion theorem – Inner product and Unitary vector spaces
	    1.6 Orthonormal sets - Schwarz inequality						

	UNIT II (18 hours) (K1, K2, K3, K4, K5 & K6) **COMPLEX ANALYSIS** 2.1 Analytic functions – Cauchy-Riemann conditions 2.2 Single and multi-valued functions 2.3 Cauchy's integral theorem and formula 2.4 Taylor's theorem 2.5 Laurent's theorem 2.6 Poles and Residues – Cauchy's residue theorem						

	UNIT III (18 hours) (K1, K2, K3, K4 & K5)
	MATRICES
	    3.1 Types of Matrices and their properties
	    3.2 Rank of a Matrix -Conjugate of a matrix
	    3.3 Adjoint of a matrix - Inverse of a matrix - Hermitian and Unitary Matrices
	    3.4 Trace of a matrix- Transformation of matrices
	    3.5 Characteristic equation - Eigen values and Eigen vectors
	    3.6 Cayley–Hamilton theorem –Diagonalization						

	UNIT IV (18 hours) (K1, K2, K3, K4 , K5 & K6) **FOURIER TRANSFORMS & LAPLACE TRANSFORMS** 4.1 Laplace transforms and inverse Laplace transforms 4.2 Solution of linear differential equations with constant co-efficients – evaluation ofintegrals 4.3 Fourier transforms – Fourier sine and cosine transforms-Convolution theorem 4.4 Differentiation and integration of transforms - Dirac delta functions Application 4.5 Application: Diffusion equation: Flow of heat in an infinite and in a semi - infinite medium - Wave equation 4.6 Vibration of an infinite string and of a semi - infinite string
	UNIT V (18 hours) (K1, K2, K3, K4 & K5) **DIFFERENTIAL EQUATIONS** 5.1 Differential equations – Order and degree of a differential equation 5.2 Solution of first order differential equation by the method of separation of variables 5.3 Solution of Linear differential equation of first order by the method of Integrating factor – Problems 5.4 Solution of first order differential equation reducible to linear form (Bernoulli's equation) - Problems 5.5 Solution of Second order differential equations with constant coefficients – Problems 5.6 Power series solution: Frobenius' method
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1.Sathyaprakash – Mathematical Physics – S.Chand & Sons, Reprint 2006. 2. George Arfken and Hans J Weber, 2012, Mathematical Methods for Physicists – A Comprehensive Guide (7th edition), Academic press. 3. P.K. Chattopadhyay, 2013, *Mathematical Physics* (2nd edition), New Age, New Delhi 4. A W Joshi, 2017, Matrices and Tensors in Physics, 4th Edition (Paperback), New Age International Pvt.Ltd., India 5. B. D. Gupta, 2009, *Mathematical Physics* (4th edition), VikasPublishing House, New Delhi. 6. H. K. Dass and Dr. Rama Verma, 2014, Mathematical Physics, Seventh Revised Edition, S. Chand & Company Pvt. Ltd., New Delhi.

Referen ce Books	1. E. Kreyszig, 1983, Advanced Engineering Mathematics, Wiley Eastern, New Delhi, 2. D. G. Zill and M. R. Cullen, 2006, Advanced Engineering Mathematics, 3rd Ed. Narosa, New Delhi. 3. S. Lipschutz, 1987, Linear Algebra, Schaum's Series, McGraw - Hill, New York 3. E. Butkov, 1968, Mathematical Physics Addison - Wesley, Reading, Massachusetts. 4. P. R. Halmos, 1965, Finite Dimensional Vector Spaces, 2nd Edition, Affiliated EastWest, New Delhi. 5. C. R. Wylie and L. C. Barrett, 1995, Advanced Engineering Mathematics, 6 th Edition, International Edition, McGraw-Hill, New York
Web resource	1. www.khanacademy.org 2. https://youtu.be/LZnRlOA1_2I 3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath 4. https://www.youtube.com/watch?v=_2jymuM7OUU&list=PLhkiT_RYTEU27vS_SlED56gNjVJGO2qaZ 5. https://archive.nptel.ac.in/courses/115/106/115106086/

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Understand use of bra-ket vector notation and explain the meaning of complete orthonormal set of basis vectors, and transformations and be able to apply them
CO2	Able to understand analytic functions, do complex integration, by applying Cauchy Integral Formula. Able to compute many real integrals and infinite sums via complex integration.
CO3	Analyze characteristics of matrices and its different types, and the process of diagonalization.
CO4	Solve equations using Laplace transform and analyze the Fourier transformations of different function, grasp how these transformations can speed up analysis and correlate their importance in technology
CO5	To find the solutions for physical problems using linear differential equations and to solve boundary value problems using Green's function. Apply special functions in computation of solutions to real world problems

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	H	H
CO2	M	H	H	H	H	H
CO3	H	H	H	M	M	H
CO4	H	H	H	H	M	H
CO5	H	M	H	H	M	H

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	H	H	H
CO2	H	H	H	H	H	H
CO3	H	H	H	M	M	H
CO4	H	H	H	H	M	H
CO5	H	M	H	H	M	H

Title of the Course	CLASSICAL MECHANICS AND RELATIVITY						
Paper No.	Core II						
Category	Core	Year	I	Credits	4	Course Code	PCPHB24
		Semester	I				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	• Knowledge of fundamentals of mechanics, Foundation in mathematical methods.						
Objectives of the course	• To understand fundamentals of classical mechanics. • To understand Lagrangian formulation of mechanics and apply it to solve equation of motion. • To understand Hamiltonian formulation of mechanics and apply it to solve equation of motion. • To discuss the theory of small oscillations of a system. • To learn the relativistic formulation of mechanics of a system.						
Course Outline	**UNIT I: (15 hours) (K1, K2, K3, K4 & K5)** **PRINCIPLES OF CLASSICAL MECHANICS** 1.1 Newton's equations - Mechanics of a single particle – Newton's equation and conservation laws for system of particles 1.2 Coordinate systems – Degrees of freedom - configuration space -constraints – holonomic & non-holonomic constraints – Some more examples of holonomic & non-holonomic constraints - Forces of Constraint 1.3 Difficulties introduced by the constraints and their removal 1.4 Generalized coordinates — transformation equations – principle of virtual work 1.5 Body and space reference system – Euler's angles – Euler's equations of motion for a rigid body 1.6 Force-free motion of a symmetrical top						
	UNIT II: (12 Hours) (K1, K2, K3, K4, K5 & K6) **LAGRANGIAN FORMULATION** 2.1 D'Alembert's principle – Lagrangian equations of motion for conservative systems from D'Alembert's Principle – Procedure for formation of Lagrange's equations 2.2 Lagrange's equations in presence of Non-conservative forces 2.3 Generalized potential – Lagrangian for a charged particle moving in an Electromagnetic field (Gyroscopic forces) 2.4 Hamilton's principle and Lagrange's equations 2.5 Invariance under Galilean transformation 2.6 Applications: (i) simple pendulum (ii) Atwood's machine (iii) projectile motion.						
	UNIT III: : (15 Hours) (K1, K2, K3, K4, K5 & K6) **HAMILTONIAN FORMULATION** 3.1 Generalized momentum and cyclic coordinates – conjugate momentum						

	3.2 Hamiltonian function H and conservation of energy : Jacobi's Integral – Conservation of energy – Physical significance 3.3 Hamilton's canonical equations of motion 3.4 Hamilton's equations in different co-ordinate systems 3.5 Δ variations - Principle of least action 3.6 Applications: (i) simple pendulum (ii) one dimensional simple harmonic oscillator (iii) motion of particle in a central force field.
	UNIT IV: (15 Hours) (K1, K2, K3, K4, K5 & K6) **SMALL OSCILLATIONS** 4.1 Introduction – Potential energy and equilibrium – one dimensional oscillator - stable, unstable and Neutral equilibrium 4.2 The Lagrangian of one dimensional oscillator and its solution - General theory of small oscillations 4.3 Secular equations and Eigen value equations - solution to Eigen value equations 4.4 Two coupled oscillators - Formulation of the problem - Lagrangian equation of two coupled oscillators and its solution – transformation to normal coordinates – frequencies of normal modes 4.5 Example of two coupled oscillator: Two coupled pendulum 4.6 Vibrations of linear triatomic molecule.
	UNIT V: (18 Hours) (K1, K2, K3, K4, K5 & K6) **RELATIVITY** 5.1 Frame of reference - Inertial and non-inertial frames – Galilean Transformations – Principle of relativity – Transformation of force from from one inertial system to another – covariance of the physical laws 5.2 Principle of relativity and speed of light – The Michelson-Morley experiments – Postulates of special theory of relativity 5.3 Lorentz transformation equations – length contraction and time dilation – Twin paradox in special relativity – Relativistic addition of velocities – Relativistic Doppler's effect 5.4 Conservation of momentum at relativistic speeds – variation of mass with velocity – Relativistic energy - Einstein's mass-energy relation – Examples mass-energy conversion 5.5 Relation between momentum and energy and conservation laws – Transformation of momentum and energy – Lorentz transformation of Force 5.6 Minkowski's space – four vectors – position, velocity, momentum, acceleration and force in four vector notation and their transformations
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

Textbooks	1. H. Goldstein, 2002, *Classical Mechanics*, 3rd Edition, Pearson Edu.
	2. J. C. Upadhyaya, *Classical Mechanics*, HimalayaPublshing. Co.New Delhi.
	3. R. Resnick, 1968, *Introduction to Special Theory of Relativity,* Wiley Eastern, New Delhi.
	4. R. G. Takwala and P.S. Puranik, Introduction to Classical Mechanics – Tata – McGraw Hill, New Delhi, 1980.
	5. N. C. Rana and P.S. Joag, Classical Mechanics - Tata McGraw Hill, 2001
Reference Books	1. K. R. Symon,1971, *Mechanics,* Addison Wesley, London.
	2. S. N. Biswas, 1999, *Classical Mechanics*, Books & Allied, Kolkata.
	3. Gupta and Kumar, *Classical Mechanics*, KedarNath.
	4. T.W.B. Kibble, *Classical Mechanics*, ELBS.
	5. Greenwood, *Classical Dynamics*, PHI, New Delhi.
Web resources	1. http://poincare.matf.bg.ac.rs/~zarkom/Book_Mechanics_Goldstein_Classical_Mechanics_optimized.pdf
	2. https://pdfcoffee.com/classical-mechanics-j-c-upadhyay-2014-editionpdf-pdf-free.html
	3. https://nptel.ac.in/courses/122/106/122106027/
	4. https://ocw.mit.edu/courses/physics/8-09-classical-mechanics-iii-fall-2014/lecture-notes/
	5. https://www.britannica.com/science/relativistic-mechanics

CO	COURSE OUTCOMES
	At the end of the course the student will be able to
CO1	Understand the fundamentals of classical mechanics.
CO2	Apply the principles of Lagrangian and Hamiltonian mechanics to solve the equations of motion of physical systems.
CO3	Apply the principles of Lagrangian and Hamiltonian mechanics to solve the equations of motion of physical systems.
CO4	Analyze the small oscillations in systems and determine their normal modes of oscillations.
CO5	Understand and apply the principles of relativistic kinematics to the mechanical systems.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	H	M	M
CO2	M	H	H	H	M	M
CO3	M	H	H	H	M	M
CO4	M	H	H	H	M	M
CO5	M	H	H	H	M	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	H	H	H
CO2	M	H	H	H	H	H
CO3	H	H	H	M	M	H
CO4	H	H	H	H	M	H
CO5	H	M	H	H	M	H

Title of the Course	LINEAR AND DIGITAL ICs AND APPLICATIONS						
Paper No.	Core III						
Category	Core	Year	I	Credits	4	Course Code	PCPHC24
		Semester	I				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	• Knowledge of semiconductor devices, basic concepts of digital and analog electronics						
Objectives of the course	• To introduce the basic building blocks of linear integrated circuits. • To teach the linear and non-linear applications of operational amplifiers. • To introduce the theory and applications of PLL. • To introduce the concepts of waveform generation and introduce one special function ICs. • Exposure to digital IC's						
Course Outline	**UNIT I (15 hours) (K1, K2, K3, K4 & K5)** **FinFET and SET** 1.1 Multi gate transistors - Need of FinFET- Structure of FinFET - Fabrication – Mechanism of FinFET Technology-Bulk FinFET- SOI FinFET 1.2 FinFET Classifications: Gate shorted (SG), Insulated Gate (IG) and Low Power (LP) - n-FinFET and p-FinFET - Working of FinFET- I-V characteristics of FinFET 1.3 Applications of FinFET - Design of Switches, logic gates, flip-flops and Schmidt trigger using FinFET 1.4 Single Electron Transistor: Principle - Quantum dots - Coulomb blockade and electron tunneling –Construction and operation of SET 1.5 Single island RC equivalent circuit of SET- Operation Temperature - Different ways to increase Coulomb energy E c - I-V characteristics of symmetric and asymmetric junction (Coulomb Stair-Case) SET 1.6 Design of logic gates using SET - Realization of AND, OR and NOT gates using SET - Advantages and disadvantages of SET- Difference between SET and FET – Applications of SET						
	UNIT II (15 hours) (K1, K2, K3, K4, K5 & K6) **OPERATIONAL AMPLIFIER APPLICATIONS** 2.1. Instrumentation amplifier - V to I and I to V converter - Op-amp circuits using diodes - Sample and Hold circuits 2.2. Log and Antilog amplifiers –Multiplier and Divider - Electronic analog Computation 2.3. Phase shift and Wein bridge sine wave oscillators 2.4. Solution to simultaneous equations and differential equations - Schimitt Trigger - Astable, Monostable Multivibrator 2.5. Square, Triangular and Saw tooth wave generators 2.6. RC Active filters - Low pass, High pass and Band pass filter						

	UNIT III (15 hours) (K1, K2, K3, K4 & K5) **555 TIMER AND APPLICATIONS** 3.1 555 Timer - Description 3.2 Monostable operation - Frequency divider 3.3 Astable operation - Schimitt trigger 3.4 Phase Locked Loops - Basic principles 3.5 Analog phase detector 3.6 Voltage Controlled Oscillator - Voltage to Frequency conversion
	UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6) **VOLTAGE REGULATOR, D to A & A to D CONVERTERS** 4.1. Introduction, Series Op-Amp regulator 4.2. IC Voltage Regulators, IC 723 general purpose regulators, Switching Regulator 4.3. D to A Converters - Introduction, basic DAC techniques -weighted resistor DAC,R-2R ladder DAC, DAC Specifications 4.4. A to D converters -parallel comparator type ADC, counter type ADC 4.5. Successive approximation ADC and dual slope ADC, ADC Specifications
	UNIT V (15 hours) (K1, K2, K3, K4, K5 & K6) **COMBINATIONAL CIRCUITS USING TTL 74XX ICs** **&SEQUENTIAL CIRCUITS USING TTL 74XX ICs** 5.1. COMBINATIONAL CIRCUITS USING TTL 74XX ICs: Study of logic gates using 74XX ICs, 5.2. Four-bit parallel adder (IC 7483), Comparator (IC 7485) 5.3. Decoder (IC 74138, IC 74154), BCD to 7-segment decoder (IC7447), Encoder (IC74147) 5.4. Multiplexer (IC74151), Demultiplexer (IC 74154) 5.5. Sequential circuits using TTL 74XX ICs: Flip Flops (IC 7474, IC 7473), 5.6. Shift Registers, Universal Shift Register (IC 74194), 4- bit asynchronous binary counter (IC 7493)
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. D. Roy Choudhury, Shail B. Jain (2012), Linear Integrated Circuit, 4th edition, New Age International Pvt. Ltd., New Delhi, India 2. Ramakant A. Gayakwad, (2012), Op-Amps and Linear Integrated Circuits, 4th edition, Prentice Hall / Pearson Education, New Delhi. 3. B. L. Theraja and A.K. Theraja, (2014), A Textbook of Electrical Technology, S. Chand & Co. Ltd. 4. V. K. Mehta and Rohit Mehta, 2008, Principles of Electronics, S. Chand & Co, 12th Edition. 5. V. Vijayendran (2008), Introduction to Integrated Electronics (Digital & Analog), S. Viswanathan Printers & Publishers Private Ltd, Reprint V.

Reference Books	1. Sergio Franco (1997), Design with operational amplifiers and analog integrated circuits, Mc Graw Hill Education, India.
	2. Gray, Meyer (1995), Analysis and Design of Analog Integrated Circuits, Wiley International, New Delhi.
	3. Malvino and Leach (2014), Digital Principles and Applications 8th Edition, Mc Graw Hill Education India,
	4. Floyd, Jain (2009), Digital Fundamentals, 8th edition, Pearson Education, New Delhi.
	5. Jacob Millman, Christos Halkias & Chetan D. Parikh (2017), Integrated Electronics: Analog and Digital Circuit and System, McGraw Hill Education India, 2nd Edition.
Web resources	1. https://nptel.ac.in/course.html/digital circuits/
	2. https://nptel.ac.in/course.html/electronics/operational amplifier/
	3. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-7/field-effect-controlled-thyristors/
	4. https://www.electrical4u.com/applications-of-op-amp/
	5. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Learn about the basic concepts for the circuit configuration for the design of linear integrated circuits and develops skill to solve problems
CO2	Develop skills to design linear and non-linear applications circuits using Op-Amp and design the active filters circuits.
CO3	Gain knowledge about PLL and develop the skills to design the simple circuits using IC 555 timer and can solve problems related to it.
CO4	Learn about various techniques to develop A/D and D/A converters.
CO5	Acquire the knowledge about the CMOS logic, combinational and sequential circuits

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	1	3
CO3	3	3	3	3	1	3
CO4	3	3	3	3	1	3
CO5	3	3	3	2	1	1

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	1	3
CO3	3	3	3	3	1	3
CO4	3	3	3	3	1	3
CO5	3	3	3	2	1	1

Title of the Course	**PRACTICAL – I – ANALOG AND DIGITAL IC'S AND APPLICATIONS**						
Paper No.	**Core IV**						
Category	**Core**	**Year**	I	**Credits**	4	**Course Code**	**PCPHD24**
		Semester	I				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	-	-		6		6	
Pre-Requisites	• Knowledge and hands on experience of basic general and electronics experiments of Physics						
Objectives of the course	• Students will learn and understand the Basics of digital electronics. • To analyze logic processes and implement logical operations using combinational logic circuits. • To understand concepts of sequential circuits and to analyze sequential systems. • To analyze the different RC and LC oscillator circuits to determine the frequency of oscillation						
Course Outline	1. (Minimum of Twelve Experiments from the list) 2. V-I Characteristics of SCR and TRIAC. 3. Study of Rectifiers using C, L-C and Pi filters. 4. Study of Voltage - Current characteristics of UJT & UJT as a Relaxation Oscillator. 5. FET as amplifier - frequency response, input impedance and output impedance. 6. Study of V-I Characteristics of J-FET as a VVR (Voltage Variable Resistor). 7. Study of V-I Characteristics of MOSFET. 8. Op-amp - Voltage follower (Inverting) summing, difference, average amplifier- differentiator and integrator. 9. Op-amp - Solving simultaneous equations. 10. Op-amp - Design of square wave generator, triangular wave generator and saw tooth wave generator. 11. Op-amp - 4-bit D/A converter - Binary Weighted Resistor method and R-2R ladder method 12. Op-amp - Design of active Low pass, High pass, Band Pass and band rejector filter. 13. Op-amp - Study of attenuation characteristics and design of Phase Shift Oscillator. 14. Op-amp –Study of attenuation characteristics and design of Wien Bridge Oscillator. 15. IC 555 - Construction of Monostable Multivibrator, Frequency Divider 16. IC 555 -Design of Schmitt Trigger and hysteresis. 17. IC 555 - Construction of Astable multivibrator and Voltage controlled Oscillator 18. Design of Synchronous and Asynchronous Counters using IC-7476/ 7473.						

	19. Construction of 4-bit Shift Register - Ring Counter and Johnson Counter - IC7476
	20. Study of i) Multiplexer and using IC 74150
	21. ii) De-Multiplexer using IC 74154
	22. Arithmetic operations (Adder/Subtractor) Using IC 7483.
	23. Modulus counter using IC7490 and display using IC7447.
	24. Phase locked loops using IC 555.
	25. Binary adder and Subtractor using NAND gates.
	26. Code Conversion – Binary to Gray & vice-versa
Textbooks	1. Practical Physics, Gupta and Kumar, Pragati Prakasan.
	2. Kit Developed for doing experiments in Physics- Instruction manual, R. Srinivasan K. R Priolkar, Indian Academy of Sciences.
	3. Electronic Laboratory Primer a design approach, S. Poornachandra, B. Sasikala, Wheeler Publishing, New Delhi.
	4. Electronic lab manual Vol I, K ANavas, Rajath Publishing.
	5. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
Reference Books	1. Advanced Practical Physics, S.P Singh, Pragati Prakasan.
	2. An advanced course in Practical Physics, D. Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd
	3. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition.
	4. A course on experiment with He-Ne Laser, R.S. Sirohi, John Wiley & Sons (Asia) Pvt. Ltd.
	5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing.

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Identify the various digital ICs and understand their operation.
CO2	Develop a digital logic and apply it to solve real life problems.
CO3	Analyze, design and implement combinational logic circuits.
CO4	Analyze, design and implement sequential logic circuits.
CO5	Design the different oscillator circuits for various frequencies.

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	M	M	H	M	M
CO2	M	M	H	H	H	H
CO3	H	H	H	H	H	H
CO4	H	M	H	H	H	H
CO5	H	H	H	H	H	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	3	M	M
CO2	M	M	H	H	H	H
CO3	H	H	H	H	H	H
CO4	H	M	H	H	H	H
CO5	H	H	H	H	H	H

Title of the Course	ELECTIVE I A: CRYSTAL GROWTH AND THIN FILMS						
Paper No.	Discipline Centric Elective – IA						
Category	Elective	Year	I	Credits	2	Course Code	PEPHA24
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	
Pre-Requisites	Fundamentals of Crystal Physics						
Objectives of the course	● To acquire the knowledge on Nucleation and Kinetics of crystal growth ● To understand the Crystallization Principles and Growth techniques ● To study various methods of Crystal growth techniques ● To understand the thin film deposition methods ● To apply the techniques of Thin Film Formation and thickness Measurement						
Course Outline	**UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)** **CRYSTAL GROWTH KINETICS** 1.1 Basic Concepts, Nucleation and Kinetics of growth Ambient phase equilibrium 1.2 super saturation - equilibrium of finite phases equation of Thomson - Gibbs 1.3 Types of Nucleation - Formation of critical Nucleus - Classical theory of Nucleation 1.4 Homo and heterogeneous formation of 3D nuclei - rate of Nucleation 1.5 Growth from vapour phase solutions, solutions and melts - epitaxial growth 1.6 Growth mechanism and classification - Kinetics of growth of epitaxial films						
	UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6) **CRYSTALLIZATION PRINCIPLES** 2.1 Crystallization Principles and Growth techniques Classes of Crystal system 2.2 Crystal symmetry - Solvents and solutions - Solubility diagram 2.3 Super solubility - expression for super saturation - Metastable zone and introduction period - Miers TC diagram 2.4 Solution growth - Low and high temperatures solution growth 2.5 Slow cooling and solvent evaporation methods 2.6 Constant temperature bath as a Crystallizer						

	UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6) **GEL, MELT AND VAPOUR GROWTH** 3.1 Gel, Melt and Vapour growth techniques. 3.2 Principle of Gel techniques - Various types of Gel - Structure and importance of Gel - Methods of Gel growth and advantages 3.3 Melt techniques - Czochralski growth - Floating zone - Bridgeman method – Horizontal gradient freeze 3.4 Flux growth - Hydrothermal growth – Vapour phase growth 3.5 Physical vapour deposition – Chemical vapour deposition 3.6 Stoichiometry
	UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6) **THIN FILM DEPOSITION METHODS** 4.1 Thin film deposition methods of thin film preparation 4.2 Thermal evaporation, Electron beam evaporation 4.3 pulsed LASER deposition, Cathodic sputtering, 4.4 RF Magnetron sputtering, MBE 4.5 Chemical vapour deposition methods, 4.6 Sol Gel spin coating
	UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6) **THIN FILM FORMATION** 5.1 Thin Film Formation and thickness Measurement Nucleation, Film growth and structure 5.2 Various stages in Thin Film formation, Thermodynamics of Nucleation, Nucleation theories 5.3 Capillarity model and Atomistic model and their comparison 5.4 Structure of Thin Film, Roll of substrate, Roll of film thickness 5.5 Film thickness measurement - Interferometry 5.6 Quartz Crystal Oscillator techniques
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

Textbooks	1. V. Markov Crystal growth for beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy (2004) 2nd edition 2. Goswami, Thin Film Fundamentals (New Age, New Delhi, 2008) 3. M. Ohora and R. C. Reid, "Modeling of Crystal Growth Rates from Solution" 4. 4. D. Elwell and H. J. Scheel, "Crystal Growth from High Temperature Solution" 5. Heinz K. Henish, 1973, "Crystal Growth in Gels", Cambridge University Press. USA.
Reference Books	1. J.C. Brice, Crystal Growth Process (John Wiley, New York, 1986) 2. P. Ramasamy and F. D. Gnanam, 1983, "UGC Summer School Notes". 3. P. Santhana Raghavan and P. Ramasamy, "Crystal Growth Processes", KRU Publications. 4. H.E. Buckley, 1951, Crystal Growth, John Wiley and Sons, New York. 5. B.R. Pamplin, 1980, Crystal Growth, Pergman Press, London.
Web resources	1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRjLrXp3kMtrIO8kZl1D1Jp 2. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgwcy7KeTLUuBu3WF 3. https://www.youtube.com/playlist?list=PLADLRin7kNjG1Dlna9MDA53CMKFHPSi9m 4. https://www.youtube.com/playlist?list=PLXHedI-xbyr8xIl_KQFs_R_oky3Yd1Emw 5. https://www.electrical4u.com/thermal-conductivity-of-metals/

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Acquire the Basic Concepts, Nucleation and Kinetics of crystal growth
CO2	Understand the Crystallization Principles and Growth techniques
CO3	Study various methods of Crystal growth techniques
CO4	Understand the Thin film deposition methods
CO5	Apply the techniques of Thin Film Formation and thickness Measurement

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	L	M	L	H
CO2	H	H	L	H	L	M
CO3	H	M	L	H	L	M
CO4	H	M	L	M	L	M
CO5	M	H	H	H	L	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	H
CO2	H	H	L	H	L	M
CO3	H	M	L	H	L	M
CO4	H	M	L	M	L	M
CO5	M	H	H	H	L	H

Title of the Course	**ELECTIVE I B: ASTROPHYSICS**						
Paper No.	**Discipline Centric Elective – IB**						
Category	**Elective**	**Year**	I	**Credits**	2	**Course Code**	PEPHB24
		Semester	I				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Fundamental knowledge about electromagnetic spectrum, wave nature of light and about the universe and the galaxy where we live in.						
Objectives of the course	• To impart knowledge on the physical universe and its evolution. • To make the student to understand fundamental principles and techniques of astronomy and astrophysics. • To make the student to study electromagnetic radiation from stars, atomic spectra and classification of stars. • To provide information about the properties and the evolution of stars. • To render information about astronomical instrumentation.						
Course Outline	**UNIT I (12 hours) (K1, K2, K3, K4, K5 & K6)** **OBSERVATIONAL ASTRONOMY** 1.1 The electromagnetic spectrum, geometrical optics (ray diagrams, focal length, magnification etc); 1.2 diffraction (resolving power, Airy disc, diffraction limit etc); telescopes (reflecting, refracting, multiwavelength) 1.3 Basic ideas of the Solar system - Geo-centric theory - Helio-centric theory 1.4 Kepler's laws of gravitation - Newton's law of gravitation - Physical processes in the solar system 1.5 Dynamics of the solar system - physics of planetary atmospheres 1.6 Individual planets; comets, asteroids, and other constituents of the solar system						
	UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6) **PROPERTIES OF STARS** 2.1 Brightness (luminosities, fluxes and magnitudes); colours (black body radiation, the Planck, Stefan-Boltzmann and Wien's laws, effective temperature, interstellar reddening) 2.2 spectral types; spectral lines (Bohr model, Lyman & Balmer series etc, Doppler effect) 2.3 Hertzprung-Russell diagram; the main sequence (stellar masses, binary systems, Kepler's laws, mass-luminosity relations) 2.4 distances to stars (parallax, standard candles, P-L relationships, ms-fitting 2.5 positions of stars (celestial sphere, coordinate systems, proper motions, sidereal and universal time). 2.6 Interstellar medium: Nebulae - Novae - Super Novae - White Dwarfs						

	UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6) **THE LIFE AND DEATH OF STARS** 3.1 Energy source (nuclear fusion, p-pchain, triple-alpha, CNO cycle, lifetime of the Sun) 3.2 solar neutrinos - basic stellar structure hydro static equilibrium, equation of state 3.3 Evolution beyond the main sequence - formation of the heavy elements; supernovae 3.4 stellar remnants(white dwarfs, neutron stars, black holes, degeneracy pressure, Swarszchild radius, escape velocities). 3.5 Electrons in white Dwarfs - Neutron stars- Pulsars - Quasars 3.6 Black holes
	UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6) **GALAXIES** 4.1 Constituents of galaxies; stellar populations; the interstellar medium; HII regions - 21cm line - Hubble's law 4.2 spirals and ellipticals; galactic dynamics; galaxy rotation curves and dark matter ; active galaxies and quasars - The nucleus, the galactic disk and the galactic halo - Dark matter 4.3 Milky way - Hubble classification of galaxies 4.4 Spiral galaxies - Elliptical galaxies - Irregular galaxies 4.5 Dwarf galaxies - Masses of galaxies 4.6 Rotation curves of galaxy - the general rotation law
	UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6) **COSMOLOGY** 5.1 Galaxies and the expanding Universe; Hubble's Law; the age of the Universe; the Big Bang 5.2 cosmic microwave background (black body radiation);big bang nucleosynthesis (cosmic abundances, binding energies, matter & radiation); introductory cosmology 5.3 (the cosmological principle, homogeneity and isotropy, Olber's paradox); cosmological models (critical density, geometry of space, the fate of the Universe); dark energy and the accelerating Universe. 5.4 Cosmic rays - Discovery of Cosmic rays - Latitude effect 5.5 Azimuth effect - Altitude effect - longitude effect 5.6 Primary cosmic rays - Secondary rays - Detection Cosmic ray showers - Vanallen Belts
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

Textbooks	1.Zeilik& Gregory, Introductory Astronomy & Astrophysics,4thedition (Saunders College Publishing) 2.Morison,I.,IntroductiontoAstronomyand Cosmology, (Wiley) 3.Kutner,M.L., Astronomy: A Physical Perspective (Cambridge University Press) 4. Green,S.F.& Jones,M.H.,An Introduction to the Sunand Stars (Cambridge University Press)
Reference Books	1. Jones,M.H.&Lambourne,R.J.A.,An Introduction to Galaxies & Cosmology (Cambridge UniversityPress) 2. Carroll,B.W.&Ostlie,D.A.,An Introduction to ModernAstrophysics (Pearson) 3. Shu,F.H.,The Physical Universe, An Introduction to Astronomy, (University Science Books) 4. Motz,L.&Duveen,A.,The Essentials of Astronomy, (ColombiaUniversityPress)
Web resources	1. https://www.coursera.org/courses?query=astrophysics 2. https://www.space.com 3. https://www.britanica.com 4. https://science.nasa.gov https://merriam-webster.com

CO	COURSE OUTCOMES
	At the end of the course, the student will be able to:
CO1	Recall and understand the electromagnetic ration from celestial objects. Analyze the wave nature of light in the form of ray diagram. Apply the knowledge of phenomenon of diffraction and asses, how diffraction limits the resolution of any system having a lens or mirror. Distinguish between reflecting and refracting telescopes and their usage.
CO2	Correlate luminosity, flux and magnitude, related to the brightness of a star. Analyze the evolution of stars using HR diagram. Apply and examine the various laws related to temperature of a star. Assess the distance of stars, measured using trigonometric parallax method. Understand the position of star in the celestial sphere. Distinguish between sideral and universal time.
CO3	Define nuclear fusion, which is the fundamental energy source of stars. Analyze, how neutrinos are born during the process of nuclear fusion in the sun. Recall and explain the CNO cycle – the main source of energy of hotter stars. Comprehend stellar evolution, including red giants, supernovas, neutron stars, pulsars, white dwarfs and black holes, using evidence and presently accepted theories
CO4	Remember and illustrate the structure of our Milky way galaxy. Classify the types of galaxies. Understand the presence of dark matter in the universe. Explain, howquasars and active galaxies are powered by supermassive black holes which produce copious luminosity.

CO5	Explain cosmology, a branch of astronomy that involves evolution of the universe, from the Big Bang to today and on into the future. Define Hubble's law of cosmic expansion. Analyze and assess the big bang nucleosynthesis universe that explains the relative

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	H	L	M	L
CO2	H	M	H	L	M	L
CO3	H	M	H	L	M	L
CO4	H	M	H	L	M	L
CO5	H	M	H	L	M	L

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	H	L	M	L
CO2	H	H	H	L	M	M
CO3	H	M	H	M	H	L
CO4	M	L	M	H	M	H
CO5	L	M	L	L	M	L

Title of the Course	ELECTIVE II A: ADVANCED OPTICS						
Paper No.	**Generic Elective IIA**						
Category	**Elective II**	**Year**	I	**Credits**	2	**Course Code**	PEPHC24
		Semester	I				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Knowledge of ray properties and wave nature of light						
Objectives of the course	• To know the concepts behind polarization and could pursue research work on application aspects of laser • To impart an extensive understanding of fiber and non-linear optics • To study the working of different types of LASERS • To differentiate first and second harmonic generation • Learn the principles of magneto-optic and electro-optic effects and its applications						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4 & K5)** **NON-LINEAR OPTICS** 1.1 Basic principles 1.2 Harmonic generation-Second harmonic generation-Kurtz-Perry powder method 1.3 Third harmonic generation – Z scan method 1.4 Optical mixing - Phase matching 1.5 Parametric generation of light 1.6 Self-focusing of light						
	UNIT II (09 hours) (K1, K2, K3, K4, K5 & K6) **LASERS** 2.1 Basic principles – Spontaneous and stimulated emissions 2.2 Components of the laser – Resonator and lasing action 2.3 Types of lasers and its applications-Solid state lasers 2.4 Ruby laser - Nd:YAG laser 2.5 gas lasers-He-Ne laser-CO_2 laser 2.6 Chemical lasers--HCl laser – Semiconductor laser						
	UNIT III (09 hours) (K1, K2, K3, K4 & K5) **FIBER OPTICS** 3.1 Introduction – Total internal reflection – The optical fiber - Glass fibers 3.2 The coherent bundle – The numerical aperture 3.3 Attenuation in optical fibers-Single and multi-mode fibers						

	3.4 Pulse dispersion in multimode optical fibers 3.5 Ray dispersion in multimode step index fibers – Parabolic-index fibers 3.6 Fiber-optic sensors: precision displacement sensor- Precision vibration sensor
	UNIT IV (09 hours) (K1, K2, K3, K4 , K5 & K6) **FIBER LOSSES** 4.1 Attenuation in optical fibers-Attenuation units 4.2 Absorption Losses- Intrinsic and Extrinsic absorption 4.3 Linear Scattering losses – Rayleigh scattering and Mie scattering 4.4 Nonlinear Scattering losses- Stimulated Brillouin and Raman Scattering 4.5 Bending Losses- Core and cladding losses 4.6 Dispersion in optical fibers- material dispersion-waveguide dispersion – intermodal dispersion
	UNIT V (09 hours) (K1, K2, K3, K4 & K5) **MAGNETO-OPTICS AND ELECTRO-OPTICS** 5.1 Magneto-optical effects 5.2 Zeeman effect – inverse Zeeman effect 5.3 Faraday effect – Voigt effect – Cotton-mouton effect 5.4 Kerr magneto-optic effect – Electro-optical effects 5.5 Stark effect – Inverse stark effect 5.6 Electric double refraction – Kerr electro-optic effect – Pockels electro-optic effect
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Text Books	1. B. B. Laud, 2017, Lasers and Non – Linear Optics, 3rd Edition, New Age International (P) Ltd. 2. R. Murugeshan, Optics and spectroscopy, 8th revised Edition, S.Chand & Company LTD. 3. AjoyGhatak, 2017, Optics, 6th Edition, McGraw – Hill Education Pvt. Ltd. 4. William T. Silfvast, 1996, Laser Fundamentals Cambridge University Press, New York 5. J. Peatros, Physics of Light and Optics, a good (and free!) electronic book 6. B. Saleh, and M. Teich, Fundamentals of Photonics, Wiley-Interscience,
Reference Books	1. F. S. Jenkins and H. E. White, 1981, Fundamentals of Optics, (4th Edition), McGraw – Hill International Edition. 2. Dieter Meschede, 2004, Optics, Light and Lasers, Wiley – VCH, Varley GmbH. 3. Lipson, S. G. Lipson and H. Lipson, 2011, Optical Physics, 4th Edition, Cambridge University Press, New Delhi, 2011. 4. Y. B. Band, Light and Matter, Wiley and Sons (2006)

	5. R. Guenther, Modern Optics, Wiley and Sons (1990)
Web resources	1. https://www.youtube.com/watch?v=WgzynezPiyc 2. https://www.youtube.com/watch?v=ShQWwobpW60 3. https://www.ukessays.com/essays/physics/fiber–optics–and–it-applications.php 4. https://www.youtube.com/watch?v=0kEvr4DKGRI 5. http://optics.byu.edu/textbook.aspx

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Discuss the transverse character of light waves and different polarization phenomenon
CO2	Discriminate all the fundamental processes involved in laser devices and to analyze the design and operation of the devices
CO3	Demonstrate the basic configuration of a fiber optic – communication system and advantages
CO4	Identify the properties of nonlinear interactions of light and matter
CO5	Interpret the group of experiments which depend for their action on an applied magnetics and electric field

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	L	H	L	M
CO2	H	H	L	M	L	H
CO3	H	H	H	H	M	H
CO4	H	M	L	H	L	H
CO5	H	L	M	H	L	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	L	M	L	M
CO2	H	H	H	M	M	M
CO3	H	H	L	M	L	M
CO4	H	M	M	H	L	M
CO5	H	M	M	H	L	M

Title of the Course	ELECTIVE II B: BIO PHYSICS						
Paper No.	**Generic Elective – IIB**						
Category	Elective	Year	I	Credits	2	Course Code	PEPHD24
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	
Pre-Requisites	Fundamental concepts of Physics and Biology						
Objectives of the course	• To understand the physical principles involved in cell function maintenance. • To understand the fundamentals of macromolecular structures involved in propagation of life. • To understand the biophysical function of membrane and neuron. • To understand various kinds of radiation and their effects on living system and to know the hazards posed by such radiations and the required precautions. • To understand the physical principles behind the various techniques available for interrogating biological macromolecules.						
Course Outline	**UNIT I (10 hours) (K1, K2, K3, K4, K5 & K6)** **CELLULAR BIOPHYSICS** 1.1 Architecture and Life Cycle of cells 1.2 Organelles of Prokaryotic and Eukaryotic cell – Cell size and shape 1.3 Fine structure of Prokaryotic and Eukaryotic cell organization 1.4 Compartment & assemblies membrane system 1.5 Extracellular matrix - Molecular mechanisms of Vesicular traffic 1.6 Electrical activities of cardiac and neuronal cells.						
	UNIT II (8hours) (K1, K2, K3, K4, K5 & K6) **MOLECULAR BIOPHYSICS** 2.1 Macromolecular structure: Protein structure 2.2 amino acids, peptide bonds, primary, secondary, tertiary and quaternary structures of proteins 2.3 Nucleic acid structure: nucleosides and nucleotides 2.4 RNA structure, DNA structure and conformation. 2.5 Special Bio-macromolecules: Metalloproteins, 2.6 Nnucleoproteins, ribozymes, chaperons and prions.						
	UNIT III (10hours) (K1, K2, K3, K4, K5 & K6) **MEMBRANE AND NEURO BIOPHYISCS** 3.1 Models membranes - Biological membranes and dynamics 3.2 Membrane Capacitors – Transport across cell and organelle membranes – Ion channels. 3.3 Nervous system: Organization of the nervous system						

	3.4 Membrane potential – Origins of membrane potential 3.5 Electrochemical potentials – Nernst equation 3.6 Goldman equation.

	UNIT IV (8hours) (K1, K2, K3, K4, K5 & K6)
	RADIATION BIO PHYSICS
	   4.1 X-Ray: Effects on bio-macromolecules
	   4.2 Gamma Radiation: Molecular effects of gamma radiation
	   4.3 Radiation effects on nucleic acids and membranes, Effects on cell and organelles
	   4.4 UV radiation: Effects on bio-macromolecules and proteins
	   4.5 Radiation hazards and protection
	   4.6 Use of radiations in cancer.

	UNIT V (9 hours) (K1, K2, K3, K4, K5 & K6)
	PHYSICAL METHODS IN BIOLOGY
	   5.1 Spectroscopy: UV-Visible absorption spectrophotometry –
	   5.2 Optical Rotatory Dispersion (ORD) – Structure Determination: X-ray Crystallography
	   5.3 Electron spin resonance (ESR) and biological applications.
	      Chromatography Thin layer chromatography (TLC)
	   5.4 Gas liquid chromatography (GLC) – Centrifugation
	   5.5 Differential centrifugation, density gradient centrifugation.
	   5.6 Electrophoresis: Gel electrophoresis, polyacrylamide gel electrophoresis.

	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. The cell: A molecular approach, Geoffrey M. Cooper, ASM Press, 2013. 2. Biophysics, Vasantha Pattabhi, N. Gautham, Narosa Publishing, 2009 3. Biophysics, P. S. Mishra VK Enterprises, 2010. 4. Biophysics, M. A Subramanian, MJP Publishers, 2005. Bioinstrumentation, L. Veerakumari, MJP Publishers, 2006.
Reference Books	1. Chemical Biophysics by Daniel A Beard (Cambridge University Press, 2008). 2. Essential cell biology by Bruce Albert et al (Garland Science) 3. Biophysics, W. Hoppe, W. Lohmann, H. Markl and H. Ziegler. Springer Verlag, Berlin (1983). 4. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A. Tuszynski, (Springer science & business media). 5. Biological spectroscopy by Iain D. Campbell, Raymond A. Dwek
Web resources	1. General Bio:http://www.biology.arizona.edu/DEFAULT.html 2. Spectroscopy: http://www.cis.rit.edu/htbooks/nmr/inside.htm 3. Electrophoresis: http://learn.genetics.utah.edu/content/labs/gel/ 4. Online biophysics programs: http://mw.concord.org/modeler/ 5. https://blanco.biomol.uci.edu/WWWResources.html

CO	COURSE OUTCOMES
	At the end of the course, the student will be able to
CO1	Understand the structural organization and function of living cells and should able to apply the cell signaling mechanism and its electrical activities.
CO2	Comprehension of the role of biomolecular conformation to function.
CO3	Conceptual understanding of the function of biological membranes and also to understand the functioning of nervous system.
CO4	To know the effects of various radiations on living systems and how to prevent ill effects of radiations.
CO5	Analyze and interpret data from various techniques viz., spectroscopy, crystallography, chromatography etc.,

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	H	M	M	M	L	M
CO2	M	H	M	L	H	L
CO3	H	L	L	L	M	L
CO4	L	M	H	M	H	M
CO5	H	M	M	H	M	L

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	M	M	H	M	L	M
CO2	L	H	M	H	H	H
CO3	L	H	L	L	L	L
CO4	M	L	H	L	H	H
CO5	H	M	M	H	L	M

Title of the Course	STATISTICAL MECHANICS						
Paper No.	Core V						
Category	**Core**	**Year**	I	**Credits**	4	**Course Code**	PCPHE24
		Semester	II				

Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	5	-	-	5

Pre-Requisites	Knowledge of Laws of thermodynamics, phase transition, entropy, ensembles, partition function, classical and quantum statistics, thermal equilibrium, Brownian motion
Objectives of the course	- To acquire the knowledge of thermodynamic potentials and to understand phase transition in thermodynamics - To identify the relationship between statistic and thermodynamic quantities - To comprehend the concept of partition function, canonical and grand canonical ensembles - To grasp the fundamental knowledge about the three types of Statistics - To get in depth knowledge about phase transitions and fluctuation of thermodynamic properties that vary with time
Course Outline	**UNIT I (12 hours) (K1, K2, K3, K4 & K5)** **THERMODYNAMICS** 1.1 Introduction - Thermodynamic potentials 1.2 Phase equilibrium 1.3 Gibb's phase rule - Entropy of mixing and Gibb's paradox 1.4 Phase transition and Ehrenfest's Classification 1.5 Landau theory of Phase transition 1.6 Critical indices- Scale transformation and dimensional analysis
	UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6) **ENSEMBLES** 2.1 Introduction - Phase space 2.2 Micro canonical, Canonical and grand canonical ensembles 2.3 Trajectories and density of states 2.4 Liouville's theorem 2.5 Partition function - Calculation of statistical quantities 2.6 Energy and density fluctuations

	UNIT III (12 hours) (K1, K2, K3, K4 & K5) **MAXWELL-BOLTZMANN STATISTICS AND BOSE-EINSTEIN STATISTICS** 3.1 Postulates of classical and quantum statistics 3.2 Density of matrix - Statistics of indistinguishable particles 3.3 Maxwell- Boltzmann distribution function - Broadening of spectral lines 3.4 Bose-Einstein statistics - Bose-Einstein distribution of gas 3.5 Equation of states - black body radiation 3.6 Bose - Einstein condensation -Landu's theory of Liquid Helium II
	UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6) **FERMI-DIRAC STATISTICS** 4.1 Fermi-Dirac distribution - Equation of states (K2, K3, K4) 3.1 Free electron gas in metals (K2, K3, K4) 3.2 Heat capacity (K2, K3, K4) 3.3 Pauli's paramagnetism (K2, K3, K4) 3.4 Thermionic emission (K2, K3, K4) 3.5 Superconductivity (K2, K3, K4)
	UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6) **REAL GAS, ISING MODEL AND FLUCTUATIONS** 5.1 Introduction - Cluster expansion for a classical gas 5.2 Virial equation of state – Calculation of the first Virial coefficient in the cluster expansion 5.3 Ising model - Mean-field theories of the Ising model in three, two and one dimensions - Exact solutions in one-dimension. 5.4 Correlation of space-time dependent fluctuations - Fluctuations and transport phenomena 5.5 Brownian motion - Langevin's theory – 5.6 Fluctuation-dissipation theorem -The Fokker-Planck equation
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. Gupta, Kumar and Sharma - 2006 *Statistical Mechanics* - PragatiPrakasan, 21st Ed., 2. Sathya Prakash and J.P Agarwal –2005*Statistical mechanics* - Kedar Nath Ram Nath,. 3. B. K. Agarwal and M. Eisner, 1998, *Statistical Mechanics,* Second Edition New Age International, New Delhi.

	4. F. Reif, 1965, *Fundamentals of Statistical and Thermal Physics,* McGraw - Hill, New York. 5. M. K. Zemansky, 1968, *Heat and Thermodynamics,* 5th edition, McGraw-Hill New York.
Reference Books	1. R. K. Pathria, 1996, *Statistical Mechanics,* 2nd edition, Butter WorthHeinemann, New Delhi. 2. B.B.Laud –2012, *Fundamentals of Statistical Mechanics* - New Age International Pvt Ltd., 3. K. Huang, 2002, *Statistical Mechanics,* Taylor and Francis, London 4. W. Greiner, L. Neiseand H.Stoecker, *Thermodynamics and Statistical Mechanics,* Springer Verlang, New York. 5. A. B. Gupta, H. Roy, 2002, *Thermal Physics*, Books and Allied, Kolkata.
Web resources	1. https://byjus.com/chemistry/third-law-of-thermodynamics/ 2. https://web.stanford.edu/~peastman/statmech/thermodynamics.html 3. https://en.wikiversity.org/wiki/Statistical_mechanics_and_thermodynamics 4. https://en.wikipedia.org/wiki/Grand_canonical_ensemble 5. https://en.wikipedia.org/wiki/Ising_model

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	To examine and elaborate the effect of changes in thermodynamic quantities on the states of matter during phase transition
CO2	To analyze the macroscopic properties such as pressure, volume, temperature, specific heat, elastic moduli etc. using microscopic properties like intermolecular forces, chemical bonding, atomicity etc. Describe the peculiar behaviour of the entropy by mixing two gases Justify the connection between statistics and thermodynamic quantities
CO3	Differentiate between canonical and grand canonical ensembles and to interpret the relation between thermodynamical quantities and partition function
CO4	To recall and apply the different statistical concepts to analyze the behaviour of ideal Fermi gas and ideal Bose gas and also to compare and distinguish between the three types of statistics.
CO5	To discuss and examine the thermodynamical behaviour of gases under fluctuation and also using Ising model

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	M	L	L
CO2	H	H	H	M	M	L
CO3	H	H	H	L	L	M
CO4	H	H	H	L	L	M
CO5	H	H	H	L	L	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	L	L	M
CO2	H	H	H	L	L	M
CO3	H	H	H	L	L	M
CO4	H	H	H	L	L	M
CO5	H	H	H	L	L	M

Title of the Course	QUANTUM MECHANICS – I						
Paper No.	Core VI						
Category	Core	Year	I	Credits	4	Course Code	PCPHF24
		Semester	II				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	Knowledge of Newton's laws of motion, Schrodinger's equation, integration, differentiation.						
Objectives of the course	➢ To develop the physical principles and the mathematical background important to quantum mechanical descriptions. ➢ To describe the propagation of a particle in a simple, one-dimensional potential. ➢ To formulate and solve the Schrodinger's equation to obtain eigenvectors and energies for particle in a three-dimensional potential. ➢ To explain the mathematical formalism and the significance of constants of motion, and see their relation to fundamental symmetries in nature To discuss the Approximation methods like perturbation theory, Variational and WKB methods for solving the Schrödinger equation.						
Course Outline	**UNIT I: (12 Hours) (K1, K2, K3, K4, K5)** **BASIC FORMALISM** 1.1: Interpretation of the wave function – Wave function for a free particle - Linear operator – Eigen functions and Eigen Values – Hermitian Operator 1.2 Postulates of Quantum Mechanics -Operator for momentum and Energy 1.3 Time dependent Schrodinger equation –Time independent Schrodinger equation 1.4 Stationary states – Ehrenfest's theorem 1.5 Definition of orthonormality - Schroedinger equation in spherical polar coordinates 1.6 Operator and Eigen values of Orbital angular momentum						
	UNIT II:(15 Hours) (K1, K2, K3, K4, K5 & K6) **ONE DIMENSIONAL AND THREE-DIMENSIONAL ENERGY EIGEN VALUE PROBLEMS** 2.1 Square well potential with rigid walls - Square well potential with finite walls – Square potential barrier – Alpha emission - Bloch waves in a periodic potential 2.2 Linear harmonic oscillator: Operator method 2.3 Particle moving in a spherically symmetric potential – System of two interacting particles 2.4 Rigid rotator 2.5 Hydrogen atom 2.6 The free particle – Three dimensional square-well potential						
	UNIT III: (18 Hours) (K1, K2, K3, K4, K5 & K6) **GENERAL FORMALISM** 3.1 Dirac notation – Equations of motions - Schrodinger representation						

	3.2 Heisenberg representation - Interaction representation 3.3Momentum representation – Operator for Position and Momentum 3.4 Operator for probability density – Equation of motion in momentum representation 3.5Symmetries and conservation laws – Unitary transformation – Parity and time reversal 3.6 Rotation in space: Conservation of Angular momentum - Space inversion- :Parity conservation
	UNIT IV: (15 Hours) (K1, K2, K3, K4, K5 & K6) **APPROXIMATION METHODS** 4.1 Time independent perturbation theory for non-degenerate energy levels – First order correction to Energy and wavefunction - Second order correction to Energy and wavefunction 4.2Stark effect in Hydrogen atom – Ground and excited state 4.3 Definition of degeneracy - Degenerate energy levels 4.4Variation method – Principle – Application to Helium atom 4.5 WKB approximation – Connection formulae (no derivation) 4.6 WKB quantization – Application to simple harmonic oscillator.
	UNIT V: (15 Hours) (K1, K2, K3, K4, K5 & K6) **ANGULAR MOMENTUM** 5.1 Commutation relations of Orbital angular momentum 5.2 Total angular momentum - Eigen values of J^2 and J_Z 5.3 Definition of angular momentum - Matrices for J^2, $J_Z J_+$, J_-, J_x and $J_y$for different values of j 5.4 Spin angular momentum –Symmetric and antisymmetric wave functions – Construction of wave-functions for spin half systems - Pauli's spin matrices 5.5 Addition of angular momenta – CG Coefficients - Computaion of CG Coefficients 5.6 CG coefficients for different values of j_1 and j_2
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Text Books	1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2^{nd}edition(37th Reprint),Tata McGraw-Hill, New Delhi, 2010. 2. G. Aruldhas, Quantum Mechanics, 2nd edition, Prentice Hall of India, New Delhi, 2009. 3. David J Griffiths, Introduction to Quantum Mechanics. 4th edition, Pearson, 2011. 4. V. Devanathan, Quantum Mechanics, 2nd edition, Alpha Science International Ltd, Oxford , 2011 5. Gupta &Kumar -Quantum Mechanics - 33rd edition -Jai Prakash Nath Publications, 2015. 6. Sathyaprakash - Quantum Mechanics - Kedar Nath Ram Nath

	Publications , 2019
	7. V. Devanathan - Quantum Mechanics - Narosa Publishing House, New Delhi, 2005.
Reference Books	1. E. Merzbacher, Quantum Mechanics, 2nd Edition, John Wiley and Sons, New York, 1970. 2. V. K. Thankappan, Quantum Mechanics, 2nd Edition, Wiley Eastern Ltd, New Delhi, 1985. 3. L. D. Landau and E. M. Lifshitz, Quantum Mechanics, 1st edition, Pergomon Press, Oxford, 1976. 4. S. N. Biswas, Quantum Mechanics, Books and Allied Ltd., Kolkata, 1999. .
Web resources	1. http://research.chem.psu.edu/lxjgroup/download_files/chem565-c7.pdf 2. http://www.feynmanlectures.caltech.edu/III_20.html 3. http://web.mit.edu/8.05/handouts/jaffe1.pdf 4. https://hepwww.pp.rl.ac.uk/users/haywood/Group_Theory_Lectures/Lecture_ 1.pdf 5. https://theory.physics.manchester.ac.uk/~xian/qm/chapter3.pdf

CO	**COURSE OUTCOMES**
	At the end of the course the student will be able to:
CO1	Demonstrates a clear understanding of the basic postulates of quantum mechanics which serve to formalize the rules of quantum Mechanics
CO2	Is able to apply and analyze the Schrodinger equation to solve one dimensional problems and three dimensional problems
CO3	Can discuss the various representations, space time symmetries and formulations of time evolution
CO4	Can formulate and analyze the approximation methods for various quantum mechanical problems
CO5	To apply non-commutative algebra for topics such as angular and spin angular momentum and hence explain spectral line splitting.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	H	M
CO2	H	H	H	H	H	M
CO3	M	H	H	M	H	M
CO4	H	H	H	H	H	M
CO5	H	H	H	M	H	M

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	H	H	M
CO2	H	H	H	H	M	M
CO3	M	H	H	M	M	M
CO4	H	H	H	H	M	M
CO5	H	H	H	M	M	M

Title of the Course	ELECTROMAGNETIC THEORY						
Paper No.	Core VII						
Category	Core	**Year**	I	**Credits**	4	**Course Code**	PCPHG24
		Semester	II				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	Knowledge of different coordinate systems, Laplace's equation, conducting & non-conducting medium, basic definitions in magnetism, propagation of electromagnetic waves, plasma						
Objectives of the course	• To acquire knowledge about boundary conditions between two media and the technique of method of separation of variables • To understand Biot – Savart's law and Ampere's circuital law • To comprehend the physical ideas contained in Maxwell's equations, Coulomb & Lorentz gauges, conservation laws • To assimilate the concepts of propagation, polarization, reflection and refraction of electromagnetic waves • To grasp the concept of plasma as the fourth state of matter						
Course Outline	**UNIT I: (15 Hours) (K1, K2, K3, K4, K5)** **ELECTROSTATICS** 1.1 Electrostatic potential - Poisson's equation and Laplace's equation –Gauss' law - Laplace equation in three dimension – Solution in Cartesian and spherical polar coordinates 1.2 Boundary value problems and Laplace equation – Boundary conditions and uniqueness theorem – conductors and second uniqueness theorem 1.3 Polarization and displacement vectors - Boundary conditions on field vectors - Examples of solutions for boundary value problems. 1.4 Molecular polarizability and electrical susceptibility - Conducting sphere in a uniform field - Dielectric sphere in a uniform field - 1.5 Electrostatic energy in the presence of dielectric – Polar molecules - Langevin equation **1.6** Non-polar molecules - Clausius-Mossotti relation - - Multipole expansion.						
	UNIT II:(15 Hours) (K1, K2, K3, K4, K5 & K6) **MAGNETOSTATICS** 2.1 Lorentz force law - Ampere's law - Biot-Savart's Law 2.2 Magnetic vector potential - Application to a long current carrying wire - and magnetic field of a localized current distribution 2.3 Magnetic moment, force and torque on a current distribution in an external field 2.4 Magneto static energy - Magnetic induction and magnetic field in macroscopic media 2.5 Boundary conditions - Uniformly magnetized sphere. 2.6 Energy in a magnetic field						

	UNIT III: (15 Hours) (K1, K2, K3, K4, K5 & K6) **MAXWELL EQUATIONS** 3.1 Faraday's laws of electro-magnetic induction - Faraday's law in vector form 3.2 Maxwell's displacement current - Maxwell's equations –Derivation 3.3 Electromagnetic Potentials **A** and φ (Vector and Scalar potentials) - Maxwell's equations in terms of Electromagnetic Potentials 3.4 Non-uniqueness of Electromagnetic Potentials - Gauge invariance - Lorentz gauge and Coulomb gauge 3.5 Conservation laws for a systems of charges and electromagnetic fields - Equation of Continuity(charge) - Momentum in EM Fields - Energy in EM fields (Poynting theorem) 3.6 Wave equation in general - Plane wave solution for free space
	UNIT IV: (15 Hours) (K1, K2, K3, K4, K5 & K6) **WAVE PROPAGATION** 4.1 Plane waves in non-conducting media - isotropic and anisotropic dielectrics 4.2 Propagation in conducting media - Calculation of Phase Velocity - Refractive Index - Skin depth - Linear and circular polarization, reflection and refraction at a plane interface 4.3 Waves in a conducting medium - Propagation of waves in a rectangular wave guide 4.4 Inhomogeneous wave equation and retarded potentials - Radiation from a localized source - Oscillating electric dipole - Radiation from an oscillating electric dipole - Poynting vector and radiated power 4.5 Radiation from a small current element - Electric field and Radiation resistance – 4.6 Radiation from a linear antenna –Electric field intensity, Magnetic field intensity, radiated power
	UNIT V: (15 Hours) (K1, K2, K3, K4, K5 & K6) **ELEMENTARY PLASMA PHYSICS** 5.1 Plasma – an introduction - conditions for plasma existence – Quasi-neutrality of plasma - The Debye shielding distance 5.2 Electron plasma oscillations – Occurrence of plasma 5.3 Charged particle in simultaneous electric and magnetic fields – charged particle in non-homogeneous magnetic field 5.4 Magneto-hydrodynamic equations 5.5 Plasma confinement in a magnetic field - Pinch effect 5.6 Plasma waves – Alfven Waves
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Text Books	1. Chopra, Agarwal - Electromagnetic Theory, 5th Edition - K. Nath & Co, Meerut, 2014. 2. Sathya Praksah - Electromagnetic Theory and Electrodynamics - Kedarnath Ramnath &Co., 2006.

	3. D. J. Griffiths, 2002, *Introduction to Electrodynamics,* 3rd Edition, Prentice-Hall of India, New Delhi. 4. J. R. Reitz, F. J. Milford and R. W. Christy, 1986, *Foundations of Electromagnetic Theory,* 3rd edition, Narosa Publishing House, New Delhi. 5. J. D. Jackson, 1975, *Classical Electrodynamics,* Wiley Eastern Ltd. New Delhi. 6. J. A. Bittencourt, 1988, *Fundamentals of Plasma Physics,* Pergamon Press, Oxford. 7. Gupta, Kumar and Singh, Electrodynamics, S.Chand & Co., New Delhi
Reference Books	1. W. Panofsky and M. Phillips, 1962, *Classical Electricity and Magnetism,* Addison Wesley, London. 2. J. D. Kraus and D. A. Fleisch, 1999, *Electromagnetics with Applications,* 5th Edition, WCB McGraw-Hill, New York. 3. B. Chakraborty, 2002, *Principles of Electrodynamics,* Books and Allied, Kolkata. 4. P. Feynman, R. B. Leighton and M. Sands, 1998, *The Feynman Lectures on Physics*, Vols. 2, Narosa Publishing House, New Delhi. 5. Andrew Zangwill, 2013, Modern Electrodynamics, Cambridge University Press, USA.
Web resources	1. http://www.plasma.uu.se/CED/Book/index.html 2. http://www.thphys.nuim.ie/Notes/electromag/frame-notes.html 3. http://www.thphys.nuim.ie/Notes/em-topics/em-topics.html 4. http://dmoz.org/Science/Physics/Electromagnetism/Courses_and_Tutorials/ 5. https://www.cliffsnotes.com/study-guides/physics/electricity-and-magnetism/electrostatics

CO	COURSE OUTCOMES
	At the end of the course the student will be able to:
CO1	Solve the differential equations using Laplace equation and to find solutions for boundary value problems
CO2	Use Biot-Savart's law and Ampere circuital law to find the magnetic induction & magnetic vector potential for various physical problems
CO3	Apply Maxwell's equations to describe how electromagnetic field behaves in different media
CO4	Apply the concept of propagation of EM waves through wave guides in optical fiber communications and also in radar installations, calculate the transmission and

	reflection coefficients of electromagnetic waves
CO5	Investigate the interaction of ionized gases with self-consistent electric and magnetic fields

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	L	M	M
CO2	H	H	H	L	M	M
CO3	H	H	H	L	M	M
CO4	H	H	H	L	M	M
CO5	H	H	H	L	M	M

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	L	M	M
CO2	H	H	H	L	M	M
CO3	H	H	H	L	M	M
CO4	H	H	H	L	M	M
CO5	H	H	H	L	M	M

Title of the Course	PRACTICAL II – GENERAL EXPERIMENTS						
Paper No.	Core VIII						
Category	Core	Year	I	Credits	4	Course Code	PCPHH24
		Semester	II				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	-	-	4			4	
Pre-Requisites	• Knowledge and handling of basic general experiments of Physics						
Objectives of the course	• To understand the concepts and principles behind in experimental physics. • To teach the students to measure the electrical, mechanical, thermal and magnetic properties of materials. • Students are trained to handle advanced sophisticated equipments and analyze the data.						
Course Outline	**(Minimum of Twelve Experiments from the list)** 1. Cornu's method - Determination of Young's modulus of the material beam by elliptical fringes. 2. Cornu's method - Determination of Young's modulus of the material beam by hyperbolic fringes. 3. Determination of Stefan's constant. 4. Band gap energy - using point contact diode (Ge and Si) 5. Hartmann's formula - Determination of wavelength of spectral lines in mercury spectrum. 6. Determination of Rydberg's constant - Hydrogen and Neon spectrum. 7. Solar spectrum - Hartmann's interpolation formula. 8. Co-efficient of linear expansion - Air wedge method. 9. Viscosity of liquid - Meyer's disc. 10. F.P.Etalon - using Spectrometer. 11. Specific charge of an electron –Magnetron method. 12. Energy bandgap of a Semiconductor - Four Probe method (as a function of temperature). 13. Edser and Butler fringes - Thickness of air film. 14. Spectrometer - Charge of an electron. 15. Spectrometer - Polarisability of liquids by finding the refractive indices at different wavelengths. 16. Permittivity of a liquid using RFO. 17. B-H loop using Anchor ring. 18. Determination of strain hardening co-efficient. 19. Determination of Audio frequencies - Bridge method. 20. Specific heat of a liquid - Ferguson's method. 21. Measurement of Numerical aperture (NA) of a telecommunication graded index optic fiber (for different length of fibers).						

	22. Fiber attenuation of the given optical fiber (between different lengths of fibers).
	23. Biprism - Wavelength of monochromatic source - using Spectrometer.
	24. Determination of specific rotatory power of a liquid using polarimeter.
	25. Compressibility of a liquid using ultrasonic interferometer.
	26. Lasers: study of laser beam parameters.
Textbooks	1. Practical Physics, Gupta and Kumar, PragatiPrakasan.
	2. Kit Developed for doing experiments in Physics- Instruction manual, R.Srinivasan K.R Priolkar, Indian Academy of Sciences.
	3. Electronic Laboratory Primer a design approach, S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi.
	4. Electronic lab manual Vol I, K ANavas, Rajath Publishing.
	5. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
Reference Books	1. Advanced Practical Physics, S.P Singh, PragatiPrakasan.
	2. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd
	3. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition.
	4. A course on experiment with He-Ne Laser, R.S. Sirohi, John Wiley & Sons (Asia) Pvt. Ltd.
	5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing.

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Measure electrical, magnetic and thermo-dynamical properties of solids.
CO2	Measure the thickness of glass plate (mechanical property) by using cornu's method
CO3	To find the wavelength of different colors through solar, mercury and hydrogen spectrum
CO4	Calculate the acceptance angle and light gathering capability and attenuation properties of optical fiber and find out the Viscosity, specific rotary power and polarizability of different liquids through various experiments
CO5	Develop the skills to take an accurate reading and analyze the results of experiments and to solve problems while handling with analytical instruments.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	H	H	M	H
CO2	M	H	H	M	M	M
CO3	M	H	M	H	H	H
CO4	H	M	H	M	H	M
CO5	M	H	H	M	M	H

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	L	H	H	H
CO2	H	H	L	M	L	H
CO3	H	H	M	M	M	H
CO4	H	H	M	H	M	H
CO5	H	H	L	M	H	H

Title of the Course	ELECTIVE III A: ADVANCED MATHEMATICAL PHYSICS						
Paper No.	Elective III						
Category	Elective	**Year**	I	Credits	2	Course Code	PEPHE24
		Semester	II				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Good knowledge in basic mathematics						
Objectives of the course	● To educate and involve students in the higher level of mathematics and mathematical methods relevant and applicable to Physics.						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4 & K5)** **TENSORS** 1.1 Introduction - Transition of coordinates 1.2 Einstein's summation convention 1.3 Contravariant, co-variant and mixed tensors 1.4 Rank of a tensor - Tensors of higher ranks 1.5 Kronecker delta symbol - Invariant tensors - Levi civita symbol 1.6 Reciprocal tensors - Relative and absolute tensors						
	UNIT II (09 hours) (K1, K2, K3, K4, K5 & K6) **TENSOR CALCULUS** 2.1 Algebraic operations of tensors –Addition and subtraction of tensors 2.2 Outer product, Contraction 2.3 Inner product and Quotient law 2.4 Symmetric and anti-symmetric tensors 2.5 Metric tensor - Basic idea of Christoffel's 3-index symbols – Transformation of Christoffel symbols 2.6 Covariant derivative of a tensor						
	UNIT III (09 hours) (K1, K2, K3, K4 & K5) **DISCRETE GROUPS** 3.1 Definition of a group, subgroup, class, 3.2 Invariant subgroup, Homomorphism and isomorphism between two groups. 3.3 Point groups - Representation of a group, unitary representations 3.4 Reducible and irreducible representations						

	3.5 Schur's lemmas, Great orthogonality theorem, 3.6 Character table, Construction of character table for C_{3V} and C_{4V} group

	UNIT IV (09 hours) (K1, K2, K3, K4, K5 & K6)
	CONTINUOUS GROUPS
	   4.1 Infinitesimal generators, Lie algebra;
	   4.2 Rotation group, representations of the Lie algebra of the rotation group
	   4.3 Representation of the rotation group,
	   4.4 D-matrices and their basic properties.
	   4.5 Addition of two angular momenta and
	   4.6 C.G. coefficients, Wigner-Eckart theorem

	UNIT V (09 hours) (K1, K2, K3, K4, K5 & K6)
	SPECIAL UNITARY GROUPS
	   5.1 Definition of unitary, unimodular groups SU(2) and SU(3).
	   5.2 Lie algebra of SU(2). Relation between SU(2) and rotation group.
	   5.3 Lie algebra of SU(3)-Gellmann's matrices.
	   5.4 Direct product of two SU(3) representations,
	   5.5 SU(3) symmetry in elementary particle physics
	   5.6 SU(2) and SU(3) classification of hadrons.

	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. Sathyaprakash - Mathematical Physics - S. Chand & Sons, Reprint 2006. 2. A. W. Joshi, Group Theory for Physicists 3. D. B. Lichtenberg, Unitary Symmetry and Elementary Particles 4. E. Butkov, Mathematical Physics 5. R. Geroch, Mathematical Physics, The University of Chicago press (1985).
Reference Books	1. M. Hamermesh *Group Theory* 2. M. E. Rose: Elementary Theory of Angular Momentum 3. Georgi : Lie Groups for Physicists 4. E. A. Lord: Tensors, Relativity & Cosmology 5. P. Szekeres, A course in modern mathematical physics: Groups, Hilbert spaces and differential geometry, Cambridge University Press.
Web resources	1. 1https://vdoc.pub/documents/unitary-symmetry-and-elementary-particles-c4qsfejthkc0 2. https://physics.iith.ac.in/HEP_Physics/slides/poplawskitalk.pdf 3. https://www.hindawi.com/journals/amp/ 4. https://projecteuclid.org/journals/advances-in-theoretical-and-mathephysics matical-physics 5. https://www.springer.com/journal/11232

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Gained knowledge of both discrete and continuous groups
CO2	Apply various important theorems in group theory
CO3	Construct group multiplication table, character table relevant to important branches of physics.
CO4	Equipped to solve problems in tensors
CO5	Developed skills to apply group theory and tensors to peruse research

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	M	L	L	M
CO2	H	H	M	L	L	L
CO3	H	H	M	L	M	M
CO4	H	H	M	M	L	M
CO5	H	H	M	M	M	L

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	M	1	1	M
CO2	H	H	M	L	L	L
CO3	H	H	M	L	M	M
CO4	H	H	M	M	L	M
CO5	H	H	M	M	M	L

Title of the Course	ELECTIVE III B: GENERAL RELATIVITY AND COSMOLOGY						
Paper No.	**Discipline Centric Elective – III**						
Category	Elective	**Year**	I	Credits	2	**Course Code**	PEPHF24
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	
Pre-Requisites	Skill in mathematics and mechanics						
Objectives of the course	● To give an introduction to students in the areas of general relativity and cosmology						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4, K5 & K6)** **TENSORS** 　　1.1 Tensors in index notation - Kronecker and Levi Civita tensors 　　1.2 inner and outer products - contraction – 　　1.3 symmetric and antisymmetric tensors – 　　1.4 quotient law - metric tensors - covariant and contravariant tensors 　　1.5 vectors - the tangent space - dual vectors - tensors – tensor 　　1.6 products - the Levi-Civita tensor - tensors in Riemann spaces						
	UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6) 　　**TENSORS FIELD** 　2.1 Vector-fields, tensor-fields 　2.2 transformation of tensors 　2.3 gradient and Laplace operator in general coordinates 　2.4 - covariant derivatives and Christoffel connection 　2.5 - Elasticity: Field tensor - field energy tensor 　2.6 strain tensor - tensor of elasticity- curature tensor						
	UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6) 　　**GENERAL RELATIVITY** 　3.1 The spacetime interval - the metric - Lorentz transformations 　3.2 space-time diagrams - world-lines - proper time – energy 　3.3 momentum vector - energy-momentum tensor - perfect fluids – energy 　3.4 momentum conservation - parallel transport - the parallel propagator 　3.5 geodesics affine parameters - the Riemann curvature tensor 　3.6 symmetries of the Riemann tensor - the Bianchi identity						

	UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6) **TENSOR IN RELATIVITY** 4.1Ricci and Einstein tensors - Weyl tensor - Killing vectors 4.2 Principle of Equivalence - gravitational redshift 4.3 gravitation as space-time curvature - the Newtonian limit 4.4 physics in curved space-time - Einstein's equations 4.5 Weak Energy Condition - causality 4.6 spherical symmetry - the Schwarzschild metric -perihelion precession
	UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6) **COSMOLOGY** 5.1 Expansion of the Universe - thermal history - and the standard cosmological model 5.2 Friedmann - Robertson-Walker type models of the Universe 5.3 Primordial inflation and the theory of cosmological fluctuations – Theory 5.4 observations of the cosmic microwave background and of the large-scale structure of the Universe- 5.5 Dark matter and dark energy - theoretical questions and observational evidence- inflation 5.6 origin of galaxies and other open problems
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. M. R. Spiegel, *Vector Analysis, Schaum'a outline series*, McGraw Hill, New York, 1974. 2. James Hartle, *Gravity: An introduction to Einstein's general relativity,* San Francisco, Addison-Wesley, 2002 3. Sean Carroll, *Spacetime and Geometry: An Introduction to General Relativity*, (Addison-Wesley, 2004). 4. Jerzy Plebanskiand Andrzej Krasinski, *An Introduction to General Relativity and Cosmology,* Cambridge University Press 2006 Meisner, Thorne and Wheeler: *Gravitation* W. H. Freeman & Co., San Francisco 1973
Reference Books	1. Robert M. Wald: *Space, Time, and Gravity: the Theory of the Big Bang and Black Holes*, Univ. of Chicago Press. 2. J. V. Narlikar, *Introduction to Cosmology,* Jones &Bartlett 1983 3. Steven Weinberg, *Gravitation and Cosmology,* New York, Wiley, 1972. 4. Jerzy Plebanski and Andrzej Krasinski, *An Introduction to General Relativity and Cosmology,* Cambridge University Press 2006 5. R Adler, M Bazin& M Schiffer, *Introduction to General Relativity*

Web resources	1. http://www.fulviofrisone.com/attachments/article/486/A%20First%20Course%20In%20General%20Relativity%20-%20Bernard%20F.Schutz.pdf
	2. https://link.springer.com/book/9780387406282
	3. https://ocw.mit.edu/courses/8-962-general-relativity-spring-2020/resources/lecture-18-cosmology-i/
	4. https://arxiv.org/abs/1806.10122 https://uwaterloo.ca/applied-mathematics/future-undergraduates/what-you-can-learn-applied-mathematics/relativity-and-cosmology

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Skillfully handle tensors
CO2	Understanding of the underlying theoretical aspects of general relativity and cosmology
CO3	Gain knowledge on space time curvature
CO4	Equipped to take up research in cosmology
CO5	Confidently solve problems using mathematical skills

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	H	H	H	M
CO2	M	H	M	M	H	H
CO3	M	H	M	M	M	M
CO4	M	M	M	H	M	H
CO5	M	M	H	M	H	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	H	H	H	M
CO2	M	H	M	M	H	H
CO3	M	H	M	M	M	M
CO4	M	M	M	H	M	H
CO5	M	M	H	M	H	H

Title of the Course	**ELECTIVE IV A: CHARACTERIZATON OF MATERIALS**						
Paper No.	**Elective IV**						
Category	**Elective**	**Year**	I	**Credits**	2	**Course Code**	PEPHG24
		Semester	II				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Fundamentals of Heat and Thermodynamics, Basics of Optical systems, Microscopic systems, Electrical measurements and Fundamentals of Spectroscopy.						
Objectives of the course	- To make the students learn some important thermal analysis techniques namely TGA, DTA, DSC and TMA. - To make the students understand the theory of image formation in an optical microscope and to introduce other specialized microscopic techniques. - To make the students learn and understand the principle of working of electron microscopes and scanning probe microscopes. - To make the students understand some important electrical and optical characterization techniques for semiconducting materials. - To introduce the students the basics of x-ray diffraction techniques and some important spectroscopic techniques.						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4 & K5)** **THERMAL ANALYSIS** 1.1 Introduction – thermogravimetric analysis (TGA) – instrumentation 1.2 Determination of weight loss and decomposition products 1.3 Differential thermal analysis (DTA)- cooling curves 1.4 Differential scanning calorimetry (DSC) – instrumentation 1.5 Specific heat capacity measurements 1.6 Determination of thermomechanical parameters.						
	UNIT II (09 hours) (K1, K2, K3, K4, K5 & K6) **MICROSCOPIC METHODS** 2.1 Optical Microscopy: optical microscopy techniques 2.2 Bright field optical microscopy-Dark field optical microscopy 2.3 Dispersion staining microscopy 2.4 Phase contrast microscopy –differential interference contrast microscopy 2.5 Fluorescence microscopy - confocal microscopy 2.6 Oil immersion objectives - quantitative metallography - image analyzer.						
	UNIT III (09 hours) (K1, K2, K3, K4, K5 & K6) **ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY** 3.1 SEM, EDAX, : working principle and Instrumentation 3.2 EPMA, TEM: working principle and Instrumentation 3.3 Sample preparation –Data collection, processing and analysis 3.4 Scanning tunneling microscopy (STEM) 3.5 Atomic force microscopy (AFM) 3.6 Scanning new field optical microscopy.						

	UNIT IV (09 hours) (K1, K2, K3, K4 , K5 & K6) **ELECTRICAL METHODS AND OPTICAL CHARACTERISATION** 4.1 Two probe and four probe methods- van der Pauw method 4.2 Hall probe and measurement – scattering mechanism 4.3 C-V characteristics – Schottky barrier capacitance 4.4 impurity concentration – electrochemical C-V profiling – limitations 4.5 Photoluminescence – light – matter interaction– instrumentation 4.6 electroluminescence – instrumentation – Applications.
	UNIT V (09 hours) (K1, K2, K3, K4 & K5) **X-RAY AND SPECTROSCOPIC METHODS** 5.1 Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy 5.2 Raman spectroscopy, ESR, NMR, 5.3 NQR, proton induced X-ray Emission spectroscopy (PIXE), single crystal XRD 5.4 Rutherford Back Scattering (RBS) analysis-application-X-ray photoelectron spectroscopy (XPS) 5.5 Powder diffraction - Powder diffractometer -interpretation of diffraction patterns - indexing - phase identification 5.6 Residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. R. A. Stradling and P. C. Klipstain. Growth and Characterization of semiconductors. Adam Hilger, Bristol, 1990. 2. J. A. Belk. Electron microscopy and microanalysis of crystalline materials. Applied Science Publishers, London, 1979. 3. Lawrence E. Murr. Electron and Ion microscopy and Microanalysis principles and Applications. Marcel Dekker Inc., New York, 1991 4.D. Kealey and P. J. Haines. Analytical Chemistry. Viva Books Private Limited, New Delhi, 2002. 5.Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press,(2008).
Reference Books	1. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001). 2. Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, (2001). 3. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49 – 51, (2009).Volumes 49 – 51, (2009). 4. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, (1986). 5. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, ButterworthHeinemann, (1993)
Web resources	1. https://cac.annauniv.edu/uddetails/udpg_2015/77.%20Mat%20Sci(AC).pdf 2. http://www.digimat.in/nptel/courses/video/113106034/L11.html

3. https://nptel.ac.in/courses/104106122
4. https://nptel.ac.in/courses/118104008
5. https://www.sciencedirect.com/journal/materials-characterization

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Describe the TGA, DTA, DSC and TMA thermal analysis techniques and make interpretation of the results.
CO2	The concept of image formation in Optical microscope, developments in other specialized microscopes and their applications.
CO3	The working principle and operation of SEM, TEM, STM and AFM.
CO4	Understood Hall measurement, four –probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence experimental techniques with necessary theory.
CO5	The theory and experimental procedure for x- ray diffraction and some important spectroscopic techniques and their applications.

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	L	H	L	M
CO2	H	H	L	M	L	H
CO3	H	H	H	H	M	H
CO4	H	M	L	H	L	H
CO5	H	L	M	H	L	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	L	M	L	M
CO2	H	H	H	M	M	M
CO3	H	H	L	M	L	M
CO4	H	M	M	H	L	M
CO5	H	M	M	H	L	M

Title of the Course	**ELECTIVE IV B: ADVANCED SPECTROSCOPY**						
Paper No.	**Discipline Centric Elective – IV**						
Category	**Elective**	**Year**	I	**Credits**	2	**Course Code**	PEPHH24
		Semester	I				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Basic knowledge of group theory, abstract thinking ability, lasers, chemical bonds and molecular structures						
Objectives of the course	● Helps students understand and appreciate spectroscopy as a sufficiently broad field in which many sub disciplines exist. ● Make them appreciate each of these specific techniques with numerous implementations. ● To realize the progress in this field that is rapid, resulting in improved instrument capabilities and an ever-widening range of applications. ● To apply group theory in spectroscopy to shed light on molecular symmetry and determine important physical parameters.						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4, K5 & K6)** **MOLECULAR SPECTROSCOPY AND GROUP THEORY** 1.1 Group axioms –subgroup, simple group, Abelian group, cyclic group, order of a group, class 1.2 Lagrange's theorem statement and proof - Symmetry operations and symmetry elements 1.3 Application: construction of group multiplication table (not character table) for groups of order 2, 3, cyclic group of order 4, noncyclic group of order 4 1.4 reducible and irreducible representations- Unitary representations – Schur's lemmas 1.5 Great orthogonality theorem - point group -Simple applications Symmetry operations of water and ammonia 1.6 Construction of character table for C_{2v} (water) and C_{3v} (ammonia) molecules–						

	UNIT II (12 hours) (K1, K2, K3, K4, K5 & K6)
	
	   LASER SPECTROSCOPY
	
	2.1Lasers as Spectroscopy Light source
	
	2.2 Special Characteristics of Laser emission- ultra short pulses
	2.3 laser cooling -Single and multi-mode lasers- Laser tenability
	2.4 Fluorescence spectroscopy with lasers-
	2.5 Laser Raman Spectroscopy – Non-linear Spectroscopy
	2.6 Applications of Laser Spectroscopy in medical fields, materials science
	     research

	UNIT III (12 hours) (K1, K2, K3, K4, K5 & K6) **MOSSBAUER SPECTROSCOPY** 3.1 Basic idea of Mossbauer spectroscopy - Principle- 3.2 Mossbauer effect- Recoilless emission and absorption- 3.3 Chemical shift -Effect of electric and magnetic fields 3.4 hyperfine interactions- instrumentation- 3.5 Applications: understanding molecular structures 3.6 understanding electronic structures

	UNIT IV (12 hours) (K1, K2, K3, K4, K5 & K6)
	
	XRAY PHOTOELECTRON SPECTROSCOPY
	
	   4.1 Principle – XPS spectra and its interpretation-
	   4.2 ECSA-EDAX
	   4.3 other forms of XPS – chemical shift
	   4.4 Applications : - stoichiometric analysis
	   4.5 electronic structure- XPES techniques used in astronomy
	   4.6 glass industries, paints and in biological research

	UNIT V (12 hours) (K1, K2, K3, K4, K5 & K6)
	
	   MOLECULAR MODELLING
	
	5.1 Determination of force constants
	5.2 force field from spectroscopic data
	5.3 normal coordinate analysis of a simple molecule (H2O)
	5.4 analyzing thermodynamic functions, partition functions, enthalpy, specific
	     heat
	5.5 related parameters from spectroscopic data
	5.6 molecular modelling using data from various spectroscopic studies

	PROFESSIONAL COMPONENTS
	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. William Kemp, 2019, Organic Spectroscopy (2nd Edition) MacMillan, Indian Edition. 2. C N Banwell and McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw–Hill, New Delhi. 3. D.N. Satyanarayana, 2001, *Vibrational Spectroscopy and Applications*, New Age International Publication. 4. B.K. Sharma , 2015, *Spectroscopy*, Goel Publishing House Meerut. 5. J M Hollas, 2002, Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry, RSC, Cambridge.
Reference Books	1. Demtroder. W, Laser Spectroscopy: Basic concepts and Instrumentation, SpringerLink. 2. B. P. Straughan and S. Walker, 1976, Spectroscopy Vol.I., Chapman and Hall, New York. 3. J L McHale, 2008, Molecular Spectroscopy, Pearson Education India, New Delhi. 4. David. L. Andrews, **Introduction to Laser Spectroscopy, Springer, 2020** 5. Kalsi.P.S, 2016, Spectroscopy of Organic Compounds (7th Edition) New Age International Publishers.
Web resources	1. Fundamentals of Spectroscopy - Course (nptel.ac.in) 2. http://mpbou.edu.in/slm/mscche1p4.pdf 3. https://onlinecourses.nptel.ac.in/noc20_cy08/preview 4. https://www.coursera.org/lecture/spectroscopy/nmr-spectroscopy-introduction-XCWRu 5. https://serc.carleton.edu/research_education/geochemsheets/techniques/mossbauer.html

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Align with the recent advances in semiconductor laser technology combined sensitive spectroscopic detection techniques.
CO2	Understand principle behind Mossbauer spectroscopy and apply the concepts of isomer shift and quadrupole splitting to analyse molecules.

CO3	Assimilate this XPES quantitative technique and the instrumentation associated with this, as applied in understanding surface of materials.
CO4	Employ IR and Raman spectroscopic data along with other data for structural investigation of molecules. Analyze thermodynamic functions and other parameters to evolve molecular models.
CO5	Comprehend set of operations associated with symmetry elements of a molecule, apply mathematical theory while working with symmetry operations. Apply mathematical theory while working with symmetry operations. To use group theory as a tool to characterize molecules.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	H	H
CO2	H	H	M	H	H	H
CO3	H	M	M	H	H	M
CO4	M	L	L	H	H	L
CO5	M	L	L	H	H	M

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	H	H	H
CO2	H	H	M	H	H	H
CO3	H	M	M	H	H	M
CO4	M	L	L	H	H	L
CO5	M	L	L	H	H	M

Title of the Course	SEC: SOLAR ENERGY UTILIZATION						
Paper No.	SKILL ENHANCEMENT COURSE - I						
Category	Elective	Year	I	Credits	2	Course Code	PSPH124
		Semester	II				

Instructional hours per week	Lecture	Tutorial	Lab Practice	Total		
	3	-	-	3		

Pre-Requisites	Basic knowledge of heat energy, way of transfer of heat, solar energy, materials types
Objectives of the course	- To impart fundamental aspects of solar energy utilization. - To give adequate exposure to solar energy related industries - To harness entrepreneurship skills - To understand the different types of solar cells and channelizing them to the different sectors of society - To develop an industrialist mindset by utilizing renewable source of energy
Course Outline	**UNIT I (9 hours) (K1, K2, K3, K4, K5 & K6)** **HEAT TRANSFER & RADIATION ANALYSIS** 1.1. Conduction, 1.2. Convection 1.3. Radiation 1.4. Solar Radiation at the earth's surface 1.5. Determination of solar time' 1.6. Solar energy measuring instruments.
	UNIT II (9 hours) (K1, K2, K3, K4, K5 & K6) **SOLAR COLLECTORS** 2.1. Liquid Flat Plate Collectors-Physical principles of conversion of solar radiation-General characteristics 2.2. Flat Plate Air Heating Collectors- 2.3. Physical principles of conversion of solar radiation-General characteristics 2.4. Focusing Type collector systems 2.5. Thermal performance evaluation of Focusing Collectors 2.6. Performance Testing of Solar Collectors
	UNIT III (9 hours) (K1, K2, K3, K4, K5 & K6) **SOLAR HEATERS** 3.1. Types of solar water heater 3.2. Solar heating system 3.3. Collectors

	3.4. Storage tanks 3.5. Solar ponds 3.6. Solar cooling systems.
	UNIT IV (9 hours) (K1, K2, K3, K4, K5 & K6) **SOLAR ENERGY CONVERSION** 4.1. Photo Voltaic principles 4.2. Types of solar cells 4.3. Crystalline silicon/amorphous silicon and Thermo - electric conversion 4.4. Process flow of silicon solar cells- 4.5. Different approaches on the process- texturization, 4.6. Diffusion, Antireflective coatings, metallization.
	UNIT V (9 hours) (K1, K2, K3, K4, K5 & K6) **NANOMATERIALS IN FUEL CELL APPLICATIONS** 5.1. Use of nanostructures and nanomaterials in fuel cell technology 5.2. High and low temperature fuel cells, 5.3. Cathode and anode reactions, 5.4. Fuel cell catalysts, electrolytes, ceramic catalysts. 5.5. Use of Nano technology in hydrogen production and storage. 5.6. Industrial visit – data collection and analysis - presentation
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. Solar energy utilization -G.D. Rai –Khanna publishers – Delhi 1987. 2. Maheshwar Sharon, Madhuri Sharon, Carbon "Nano forms and Applications", Mc Graw-Hill, 2010. 3. Soteris A. Kalogirou, „Solar Energy Engineering: Processes and Systems", Academic Press, London, 2009 4. Tiwari G.N, "Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002 5. Sukhatme S.P. Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
Reference Books	1. Energy – An Introduction to Physics – R.H.Romer, W.H.Freeman.(1976) 2. Solar energy thermal processes – John A.Drife and William. (1974) 3. John W. Twidell& Anthony D.Weir, 'Renewable Energy Resources,2005 4. John A. Duffie, William A. Beckman, Solar Energy: Thermal Processes, 4th Edition, john Wiley and Sons, 2013 5. Duffie, J.A., Beckman, W.A. , "Solar Energy Thermal Process", John Wiley and Sons,2007.

Web resources	1. https://pdfs.semanticscholar.org/63a5/a69421b69d2ce9f359bbfc86c63556f9a4fb 2. https://books.google.vg/books?id=l-XHcwZo9XwC&sitesec=buy&source=gbs_vpt_read 3. www.nptel.ac.in/courses/112105051 4. www.freevideolectures.com 5. http://www.e-booksdirectory.com

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Gained knowledge in fundamental aspects of solar energy utilization
CO2	Equipped to take up related job by gaining industry exposure
CO3	Develop entrepreneurial skills
CO4	Skilled to approach the needy society with different types of solar cells
CO5	Gained industrialist mindset by utilizing renewable source of energy

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	H	H	H	M
CO2	M	H	M	M	H	H
CO3	M	H	M	M	M	M
CO4	M	M	M	H	M	H
CO5	M	M	H	M	H	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	H	H	H	M
CO2	M	H	M	M	H	H
CO3	M	H	M	M	M	M
CO4	M	M	M	H	M	H
CO5	M	M	H	M	H	H

Title of the Course	QUANTUM MECHANICS – II						
Paper No.	Core IX						
Category	Core	Year	II	Credits	5	Course Code	PCPHI24
		Semester	III				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	6	-		-		6	
Pre-Requisites	Knowledge of postulates of Quantum mechanics, properties of Hermitian operators, ladder operators, degeneracy, angular momentum techniques and commutation rules						
Objectives of the course	• Formal development of the theory and the properties of angular momenta, both orbital and spin • To familiarize the students to the crucial concepts of scattering theory such as partial wave analysis and Barn approximation. • Time-dependent Perturbation theory and its application to study of interaction of an atom with the electromagnetic field • To give the students a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts • To introduce the concept of covariance and the use of Feynman graphs for depicting different interactions						
Course Outline	**UNIT I: (18 Hours) (K1, K2, K3, K4, K5)** **SCATTERING THEORY** 1.1 Introduction – Scattering Cross sections – Scattering amplitude -Relationship between scattering amplitude and differential scattering cross section 1.2 Partial waves - Partial wave analysis – Scattering by a Central potential - Ramsaur-Townsend effect (K2, K4) 1.3 Optical theorem - Scattering by an attractive square well potential (Breit Wigner formula)- Scattering length and Effective range theory for s wave 1.4 Expression for phase shifts – Integral equation 1.5 Born approximation and its validity – Scattering by a screened coulomb potential – Yukawa potential – 1.6 Transformation from centre of mass to laboratory frame						
	UNIT II:(18 Hours) (K1, K2, K3, K4, K5 & K6) **PERTURBATION THEORY** 2.1 Time dependent perturbation theory – Constant perturbation (First order perturbation) 2.2 Harmonic perturbations - Transition to a discrete state - Transition to a continuum states (Fermi's Golden rule) 2.3 Absorption and emission of radiation - Absorption and emission of radiation: The electromagnetic field - The Hamiltonian operator - Electric dipole approximation 2.4 Transition probability Einstein's A and B Coefficients - Adiabatic approximation – Sudden approximation 2.5 Semi – classical treatment of an atom with electromagnetic radiation – Selection rules for dipole radiation						

	2.6 Raman scattering - Rayleigh scattering
	UNIT III: (18 Hours) (K1, K2, K3, K4, K5 & K6) **RELATIVISTIC QUANTUM MECHANICS** 3.1 Klein-Gordon equation - Interpretation of Klein-Gordan equation - Charge and Current Densities 3.2 Particle in a coulomb field 3.3 Dirac's equation for a free particle - Dirac matrices - Properties of the gamma matrices - Traces 3.4 Plane wave solution - Negative energy states - Antiparticles 3.5 Spin of the Dirac particle (electron) 3.6 Magnetic moment of an electron due to spin
	UNIT IV: (18 Hours) (K1, K2, K3, K4, K5 & K6) **DIRAC EQUATION** 4.1 Covariant form of Dirac Equation – Probability density 4.2 Relativistic invariance of Dirac equation 4.3 Spin-orbit interaction 4.4 Radial equation for an electron in an central potential - Hydrogen atom problem - Lamb shift 4.5 T-Transformation for the Dirac equation in the presence of electromagnetic field - Magnetic resonance - Projection operators for energy and spin 4.6 Current four vector – Bilinear covariant – Feynman's theory of positron (Elementary ideas only without propagation formalism)
	UNIT V: (18 Hours) (K1, K2, K3, K4, K5 & K6) **CLASSICAL FIELDS AND SECOND QUANTIZATION** 5.1 Second quantization - Concepts of Classical mechanics - Coordinates of a field Classical fields 5.2 Euler Lagrange equation – Hamiltonian formulation – Noether's theorem 5.3 Quantization of real and complex scalar fields – Qunatization of the Schrodinger equation - Creation, Annihilation and Number operators – Fock states 5.4 Relativistic fields – Natural units - Second Quantization of K-G field 5.5 Quantization of Dirac field - Quantization of electromagnetic fields 5.6 Quantization of Schrodinger field
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Text Books	1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics,2nd Edition,Tata McGraw-Hill, New Delhi, 2010. 2. G. Aruldhas, Quantum Mechanics, 2nd Edition, Prentice-Hall of India, NewDelhi,2009 3. L. I. Schiff, Quantum Mechanics, 3rd Edition, International Student Edition, McGraw-Hill Kogakusha, Tokyo, 1968 4. V. Devanathan, Quantum Mechanics, 1st Edition, Narosa Publishing House, New Delhi, 2005.

	5. NouredineZettili, Quantum mechanics concepts and applications, 2nd Edition, Wiley, 2017 6. Satyaprakash - Quantum Mechanics - Kedar Nath Ram Nath Publications – 2019 7. Gupta & Kumar - Quantum Mechanics - 33rd edition -Jai Prakash Nath Publications- 2015 8. V. Devanathan - Relativistic Quantum Mechanics and Quantum Field Theory – Narosa publishing house
Reference Books	1. P. A. M. Dirac, The Principles of Quantum Mechanics, 4th Edition, Oxford University Press, London, 1973. 2. B. K. Agarwal & HariPrakash, Quantum Mechanics, 7th reprint, PHI Learning Pvt. Ltd., New Delhi, 2009. 3. Deep Chandra Joshi, Quantum Electrodynamics and Particle Physics,1st edition, I. K. International Publishing house Pvt. Ltd., 2006 4. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, 4th Edition, Macmillan India, New Delhi. 5. E. Merzbacher, Quantum Mechanics, 2nd edition, John Wiley and Sons, New York, 1970
Web resources	1. https://ocw.mit.edu/courses/physics/8-05-quantum-physics-ii-fall-2013/lecture notes/MIT8_05F13_Chap_09.pdf 2. http://www.thphys.nuim.ie/Notes/MP463/MP463_Ch1.pdf 3. http://hep.itp.tuwien.ac.at/~kreuzer/qt08.pdf 4. https://www.cmi.ac.in/~govind/teaching/rel-qm-rc13/rel-qm-notes-gk.pdf 5. https://web.mit.edu/dikaiser/www/FdsAmSci.pdf

CO	COURSE OUTCOMES
At the end of the course the student will be able to	
CO1	Familiarize the concept of scattering theory such as partial wave analysis and Born approximation
CO2	Give a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts
CO3	Discuss the relativistic quantum mechanical equations namely, Klein-Gordon and Dirac equations and the phenomena accounted by them like electron spin and magnetic moment
CO4	Introduce the concept of covariance and the use of Feynman graphs for depicting different interactions
CO5	Demonstrate an understanding of field quantization and the explanation of the scattering matrix.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	H	H
CO2	H	H	M	H	H	H
CO3	H	M	M	H	H	M
CO4	M	L	L	H	H	L
CO5	M	L	L	H	H	M

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	H	H	H
CO2	H	H	M	H	H	H
CO3	H	M	M	H	H	M
CO4	M	L	L	H	H	L
CO5	M	L	L	H	H	M

Title of the Course	CONDENSED MATTER PHYSICS						
Paper No.	Core X						
Category	Core	Year	I	Credits	5	Course Code	PCPHJ24
		Semester	III				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	6	-		-		6	
Pre-Requisites	Basic knowledge of atomic physics, quantum mechanics and statistical mechanics						
Objectives of the course	• To describe various crystal structures, symmetry and to differentiate different types of bonding. • To construct reciprocal space, understand the lattice dynamics and apply it to concept of specific heat. • To critically assess various theories of electrons in solids and their impact in distinguishing solids. • Outline different types of magnetic materials and explain the underlying phenomena. • Elucidation of concepts of superconductivity, the underlying theories – relate to current areas of research.						

Course Outline	**UNIT I (18 hours) (K1, K2, K3, K4 & K5)**
	CRYSTAL PHYSICS
	    1.1 Types of lattices - Miller indices – Simple crystal structures
	    1.2 Atomic Packing Factor- Crystal diffraction - Bragg's law
	    1.3 Reciprocal Lattice (sc, bcc, fcc). Structure and properties of liquid crystals
	    1.4 Diffraction Conditions - Laue equations - Brillouin zone
	    1.5 Structure factor - Atomic form factor
	    1.6 Inert gas crystals- - Cohesive energy of ionic crystals - Madelung constant - Types of crystal binding (general ideas)						

	UNIT II (18 hours) (K1, K2, K3, K4, K5 & K6)
	LATTICE DYNAMICS
	    2.1 Lattice with two atoms per primitive cell
	    2.2 Brillouin Zone-construction
	    2.3 -Group and phase velocities-Quantization of lattice vibrations
	    2.4 Phonon momentum-Inelastic scattering by phonons
	    2.5 Debye's theory of lattice heat capacity
	    2.6 Thermal Conductivity –N-process and Umkalapp processes						

	UNIT III (18 hours) (K1, K2, K3, K4, K5 & K6)
	THEORY OF METALS AND SEMICONDUCTORS
	    3.1 Free electron gas in three dimensions - Electronic heat capacity
	    3.2 Wiedemann-Franz law –Relation between electrical and thermal conductivity
	    3.3 Origin of the energy gap- Bloch theorem - Kronig-Penney model
	    3.4 Semiconductors - Intrinsic carrier concentration-density of electrons and						

	density of holes 3.5 Mobility - Impurity conductivity - Hall effect 3.6 Fermi surfaces and construction - Experimental methods in Fermi surface studies - de Hass-van Alphen effect
	UNIT IV (18 hours) (K1, K2, K3, K4 , K5 & K6) **MAGNETISM** 4.1 Diamagnetism - Quantum theory of paramagnetism - Rare earth ion 4.2 Hund's rule - Quenching of orbital angular momentum - Adiabatic demagnetization 4.3 Quantum theory of ferromagnetism - Curie point - Exchange integral 4.4 Heisenberg's interpretation of Weiss field- Ferromagnetic domains - Bloch wall 4.5 Spin waves -Quantization-- Magnons - Thermal excitation of magnons 4.6 Curie temperature and susceptibility of ferrimagnets - Theory of antiferomagnetism - Neel temperature
	UNIT V (18 hours) (K1, K2, K3, K4 & K5) **SUPERCONDUCTIVITY** 5.1 Experimental facts: Occurrence - Effect of magnetic fields - Meissner effect – Critical field 5.2 Critical current - Entropy and heat capacity - Energy gap - Microwave and infrared properties 5.3 Type I and II Superconductors-Theoretical Explanation: Thermodynamics of super conducting transition 5.4 London equation - Coherence length – Isotope effect 5.5 Cooper pairs – Bardeen Cooper Schrieffer (BCS) Theory-Nature of paring and condensation of Fermions 5.6 Single particle tunneling - Josephson tunneling - DC and AC Josephson effects - High temperature Superconductors – SQUIDS
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. S.O Pillai - Solid State Physics, 7th Edition - New Age International, Delhi, 2015. 2. Guptha Kumar – Solid State Physics, 9th Edition - K.Nath & Co. Education, 2016. 3. K.Ilangovan - Solid State Physics - MJP Publications, Chennai, 2013. 4. C. Kittel, 1996, *Introduction to SolidState Physics,* 7th Edition, Wiley, New York. 5. Rita John, Solid State Physics,Tata Mc-GrawHill Publication. 6. A. J. Dekker, *SolidState Physics*, Macmillan India, New Delhi. 7. M. Ali Omar, 1974, *Elementary SolidState Physics – Principles and Applications,* Addison – Wesley 8. H. P. Myers, 1998, *Introductory SolidStatePhysics,* 2nd Edition, Viva Book, New Delhi.

Reference Books	1. J. S. Blakemore, 1974, *Solid state Physics,* 2nd Edition, W.B. Saunder, Philadelphia
	2. H. M. Rosenburg, 1993, *The SolidState,* 3rd Edition, OxfordUniversity Press, Oxford.
	3. J. M. Ziman, 1971, Principles *of the Theory of Solids*, CambridgeUniversity Press, London.
	4. C. Ross-Innes and E. H. Rhoderick, 1976, *Introduction to Superconductivity,* Pergamon, Oxford.
	5. J. P. Srivastava, 2001, *Elements of Solid State Physics,* Prentice-Hall of India, New Delhi.
Web resources	1. http://www.physics.uiuc.edu/research/electronicstructure/389/389-cal.html
	2. http://www.cmmp.ucl.ac.uk/%7Eaph/Teaching/3C25/index.html
	3. https://www.britannica.com/science/crystal
	4. https://www.nationalgeographic.org/encyclopedia/magnetism/https://www.br
	5. inkart.com/article/Super-Conductors_6824/

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure
CO2	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.
CO3	Student will be able to comprehend the heat conduction in solids
CO4	Student will be able to generalize the electronic nature of solids from band theories.
CO5	Student can compare and contrast the various types of magnetism and conceptualize the idea of superconductivity.

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	L	H	L	M
CO2	H	H	L	M	L	H
CO3	H	H	H	H	M	H
CO4	H	M	L	H	L	H
CO5	H	L	M	H	L	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	L	M	L	M
CO2	H	H	H	M	M	M
CO3	H	H	L	M	L	M
CO4	H	M	M	H	L	M
CO5	H	M	M	H	L	M

Title of the Course	NUMERICAL METHODS AND COMPUTER PROGRAMMING						
Paper No.	**Core XI**						
Category	**Core**	**Year**	II	**Credits**	5	**Course Code**	PCPHK24
		Semester	III				

Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	5	-	-	5

Pre-Requisites	Prior knowledge on computer and basic mathematics

Objectives of the course	● To make students to understand different numerical approaches to solve a problem. ● To understand the basics of programming

Course Outline	**UNIT I (15 hours) (K1, K2, K3, K4, K5 & K6)** **SOLUTIONS OF EQUATIONS** 1.1. Zeros or Roots of an equation - Non-linear algebraic equation and transcendental equations. 1.2. Zeros of polynomials –Roots of polynomials, 1.3. Nonlinear algebraic equations and transcendental equations using Bisection Method. 1.4. Nonlinear algebraic equations and transcendental equations using Newton-Raphson method. 1.5. Nonlinear algebraic equations and transcendental equations using Methods of false position 1.6. Nonlinear algebraic equations and transcendental equations using Fixed point - Iteration method
	UNIT II (15 hours) (K1, K2, K3, K4, K5 & K6) **INTERPOLATION AND CURVE FITTING** 2.1 Interpolation with equally spaced points – Divided differences 2.2 Interpolation with equally spaced points – Newton forward interpolation 2.3 Interpolation with equally spaced points- Newton backward interpolation 2.4 Interpolation with unevenly spaced points – Lagrange interpolation 2.5 Curve fitting – Method of least squares.

	2.6 Curve fitting – Fitting a polynomial.
	UNIT III (15 hours) (K1, K2, K3, K4, K5 & K6) **DIFFERENTIATION, INTEGRATION AND SOLUTION OF** **DIFFERENTIAL EQUATIONS** 3.1 Numerical differentiation – Numerical integration – Trapezoidal rule 3.2 Simpson's rule – Error estimates 3.3 Solution to first order differential equations: Taylor series method 3.4 Solution of ordinary differential equations –Euler methods. 3.5 Solution of ordinary differential equations - Modified Euler method 3.6 Solution of ordinary differential equations – Runge-Kutta method
	UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6) **PROGRAMMING IN C- OPERATORS, ARRAYS AND STRINGS** 4.1 Introduction – Basic structure of C Programming-Character set – Keywords-Identifiers –Variables – Assigning values to variables 4.2 Operators – Arithmetic, relational, logical, assignment, increment 4.3 Arrays – Multi dimensional arrays 4.4 Initializing two dimensional arrays 4.5 Initializing string variables 4.6 Reading and writing Strings on the Arithmetic operations on strings
	UNIT V (15 hours) (K1, K2, K3, K4, K5 & K6) **SIMPLE PROGRAMMES** 5.1 User defined functions – their needs – Multi function programme 5.2 Return values and their types – Calling functions 5.3 Categories of functions – Multiplication 5.4 Diagonalization and inversion – Solution and C programming 5.5 Lagrangian interpolation – Simpson's rule 5.6 Euler method- Runge – Kutta method
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. V. Rajaraman, 1993, Computer oriented Numerical Methods, 3rd Edition. PHI, New Delhi 2. M. K .Jain, S. R. Iyengar and R. K. Jain, 1995, Numerical Methods for Scientific and Engineering Computation, 3rd Edition, New Age Intl., New Delhi 3. S. S. Sastry, Introductory Methods of Numerical analysis, PHI, New Delhi 4. F. Scheid, 1998, Numerical Analysis, 2nd Edition, Schaum's series, McGraw Hill, New York 5. T. Veerarajan and T. Ramachandran, Numerical Methods with

	Programming in C, Second Edition, Tata McGraw Hill, 2007 6. E. Balagurusamy - Computing Fundamentals and Programming, ANSI C, 3rd Edition – Tata McGraw Hill Education, Ltd., 2014. 7. G. Balaji - Numerical Methods, 9th Edition - G. Balaji Publishers, Chennai, 2008.
Reference Books	1. S. D. Conte and C. de Boor, 1981, Elementary Numerical analysis-an algorithmic approach, 3rd Edition, McGraw Hill,) 2. B. F. Gerald, and P. O. Wheatley, 1994, Applied Numerical analysis, 5th Edition, Addison-Wesley, MA. 3. B. Carnagan, H. A. Luther and J. O. Wilkes, 1969, Applied Numerical Methods, Wiley, New York. 4. S. S. Kuo, 1996, Numerical Methods and Computers, Addison-Wesley. 5. V. Rajaraman, Programming in FORTRAN / Programming in C, PHI, New Delhi
Web resources	1. https://www.scribd.com/doc/202122350/Computer-Oriented-Numerical-Methods-by-V-RajaRaman 2. https://www.scirp.org/(S(lz5mqp453edsnp55rrgjct55))/reference/referencespapers.aspx?referenceid=1682874 3. https://nptel.ac.in/course/122106033/ 4. https://nptel.ac.in/course/103106074/ 5. https://onlinecourses.nptel.ac.in/noc20_ma33/preview

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Recall the transcendental equations and analyze the different root finding methods. Understand the basic concept involved in root finding procedure such as Newton Raphson and Bisection methods, their limitations.
CO2	Relate Simultaneous linear equations and their matrix representation Distinguish between various methods in solving simultaneous linear equations.
CO3	Understand, how interpolation will be used in various realms of physics and Apply to some simple problems Analyze the newton forward and backward interpolation
CO4	Recollect and apply methods in numerical differentiation and integration. Assess the trapezoidal and Simson's method of numerical integration.
CO5	Understand the basics of C-programming and conditional statements.

CO/PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO6
CO1	H	M	H	L	L	M
CO2	H	M	H	L	L	M
CO3	H	M	H	L	L	M
CO4	H	M	H	L	L	M
CO5	H	M	H	L	L	M

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	H	L	L	M
CO2	H	M	H	L	L	M
CO3	H	M	H	L	L	M
CO4	H	M	H	L	L	M
CO5	H	M	H	L	L	M

Title of the Course	PRACTICAL – III: ADVANCED PRACTICAL EXPERIMENTS						
Paper No.	Core XII						
Category	Core	Year	II	Credits	4	Course Code	PCPHL24
		Semester	III				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
		-	6			6	
Objectives of the course	➢ To understand the concept of mechanical behavior of materials and calculation of same using appropriate equations. ➢ To calculate the thermodynamic quantities and physical properties of materials. ➢ To analyze the optical and electrical properties of materials. ➢ To provide the students hands-on experiences to conduct advanced experiments in the laboratory in lieu of the theory taught in the class. .						
Course Outline	(Minimum of Twelve Experiments from the list) 1. G.M. Counter - characteristics, Inverse square law. 2. G.M. Counter - Absorption co-efficient. 3. Determination of Carrier Concentration - Hall Effect. 4. Determination of Volume Susceptibility of a liquid by Quincke's method. 5. Determination of Mass Susceptibility of a liquid by Guoy's method. 6. Michelson Interferometer -Wavelength and separation of wavelengths. 7. Michelson Interferometer - Thickness of mica sheet. 8. F.P. Etalon using Michelson set up. 9. Determination of Wave length of Laser Beam. 10. Ultrasonic Interferometer - Velocity and Compressibility of a liquid. 11. Ultrasonic Diffraction - Velocity and Compressibility of a liquid. 12. Determination of Planck's constant. 13. B-H curve using CRO. 14. Salt Analysis using Spectrograph - CDS 15. Dielectric constant of liquids and solids by capacitance method. 16. Determination of coefficient of coupling by AC bridge method. 17. Impedance measurement using LCR bridge. 18. Four probe method - Determination of conductivity of thin films. 19. Determination of dielectric loss using CRO.						

Text Books	1. Practical Physics, Gupta and Kumar, Pragati Prakasan 2. Advanced Practical Physics, 2024, Reena Devi, Mary Jamila, Bharathi Book House, Publication. 3. A course on experiment with He-Ne Laser, R.S. Sirohi, John Wiley & Sons (Asia) Pvt. Ltd.
Reference Books	1. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd 2. Advanced Practical Physics, S.P Singh, PragatiPrakasan 3. A course on experiment with He-Ne Laser, R.S. Sirohi, John Wiley & Sons (Asia) Pvt. Ltd

CO	**Course Outcomes**
On completion of this course, students will be able to;	
CO1	Interpret and appreciate the advanced concepts in physics.
CO2	Use scientific equipment for analysis and data acquisition.
CO3	Analyse the properties (electric, magnetic, nuclear and dielectric) of solids/liquids.
CO4	Apply acquired knowledge to the analysis of experimental data.
CO5	Get exposure to work environment at research level and motivation for a lifelong learning.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	H	L	M
CO2	H	H	L	M	L	H
CO3	H	H	H	H	M	H
CO4	H	M	L	H	L	H
CO5	H	L	M	H	L	H

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	M	H	H
CO2	M	M	M	H	H	H
CO3	H	M	H	H	H	H
CO4	H	M	H	H	H	H
CO5	H	H	H	H	H	H

Title of the Course	ELECTIVE V A: PHYSICS OF NANO SCIENCE AND TECHNOLOGY						
Paper No.	Elective V						
Category	Elective	Year	II	Credits	3	Course Code	PEPHI24
		Semester	III				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	3	-		-		3	
Pre-Requisites	Basic knowledge in Solid State Physics						
Objectives of the course	➢ Physics of Nanoscience and Technology is concerned with the study, creation, manipulation and applications at nanometer scale. ➢ To provide the basic knowledge about nanoscience and technology. ➢ To learn the structures and properties of nanomaterials. ➢ To acquire the knowledge about synthesis methods and characterization techniques and its applications. ➢ Elucidation of concepts of superconductivity, the underlying theories – relate to current areas of research.						
Course Outline	**UNIT I (09 hours) (K1, K2, K3, K4 & K5)** **FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY** 1.1 Fundamentals of NANO– Historical Perspective on Nanomaterial and Nanotechnology 1.2 Classification of Nanomaterials-Metal and Semiconductor Nanomaterials 1.3 2D, 1D, 0D nanostructured materials 1.4 Quantum dots - Quantum wires 1.5 Quantum wells 1.6 Surface effects of nanomaterials.						
	UNIT II (09 hours) (K1, K2, K3, K4, K5 & K6) **PROPERTIES OF NANOMATERIALS** 2.1.Physical properties of Nanomaterials-Introduction 2.2.Melting points, specific heat capacity, and lattice constant 2.3.Mechanical behavior: Elastic properties – strength - ductility - superplastic behavior 2.4.Optical properties: - Surface Plasmon Resonance – Quantum size effects 2.5.Electrical properties - Conductivity, Ferroelectrics and dielectrics 2.6.Magnetic properties – super para magnetism – Diluted magnetic semiconductor (DMS)						
	UNIT III (09 hours) (K1, K2, K3, K4, K5 & K6) **SYNTHESIS AND FABRICATION** **3.1** Physical vapour deposition - Chemical vapour deposition 3.2 Sol-gel – Wet deposition techniques 3.3 Electrochemical deposition method – Plasma arching 3.4 Electrospinning method - ball milling technique 3.5 Pulsed laser deposition-Nanolithography 3.6 photolithography – Nanomanipulator						

	UNIT IV (09 hours) (K1, K2, K3, K4 , K5 & K6) **CHARACTERIZATION TECHNIQUES** 4.1 Powder X-ray diffraction – X-ray photoelectron spectroscopy (XPS) 4.2 UV-visible spectroscopy – Photoluminescence 4.3 Scanning electron microscopy (SEM) 4.4 Transmission electron microscopy (TEM) 4.5 Scanning probe microscopy (SPM) 4.6 Scanning tunneling microscopy (STM) – Vibrating sample Magnetometer
	UNIT V (09 hours) (K1, K2, K3, K4 & K5) **APPLICATIONS OF NANOMATERIALS** 5.1 Sensors: Nanosensors based on optical and physical properties 5.2 Electrochemical sensors – Nano-biosensors 5.3 Nano Electronics: Nanobots - display screens –GMR read/write heads 5.4 Carbon Nanotube Emitters – Photocatalytic application: Air purification, water purification 5.5 Medicine: Imaging of cancer cells – biological tags - drug delivery 5.6 Energy: fuel cells - rechargeable batteries - supercapacitors - photovoltaics.
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. A textbook of Nanoscience and Nanotechnology, Pradeep T., Tata McGraw-Hill Publishing Co. (2012). 2. Principles of Nanoscience and Nanotechnology, M.A. Shah, Tokeer Ahmad, Narosa Publishing House Pvt Ltd., (2010). 3. Introduction to Nanoscience and Nanotechnology, K. K. Chattopadhyay and A.N. Banerjee, PHI Learning Pvt. Ltd., New Delhi, (2012). 4. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press, (2002). 5. Nanotechnology and Nanoelectronics, D.P. Kothari, V. Velmurugan and Rajit Ram Singh, Narosa Publishing House Pvt.Ltd, New Delhi. (2018)
Reference Books	1. Nanostructures and Nanomaterials – HuozhongGao – Imperial College Press (2004). 2. Richard Booker and Earl Boysen, (2005) Nanotechnology, Wiley Publishing Inc. USA 3. Nano particles and Nano structured films; Preparation, Characterization and Applications, J.H.Fendler John Wiley and Sons. (2007) 4. Textbook of Nanoscience and Nanotechnology, B.S.Murty, et al., Universities Press. (2012) 5. The Nanoscope (Encyclopedia of Nanoscience and Nanotechnology), Dr. Parag Diwan and Ashish Bharadwaj (2005) Vol. IV - Nanoelectronics Pentagon Press, New Delhi.
Web	1. www.its.caltec.edu/feyman/plenty.html

resources	2. http://www.library.ualberta.ca/subject/nanoscience/guide/index.cfm 3. http://www.understandingnano.com 4. http://www.nano.gov 5. http://www.nanotechnology.com

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Understand the basic of nanoscience and explore the different types of nanomaterials and should comprehend the surface effects of the nanomaterials.
CO2	Explore various physical, mechanical, optical, electrical and magnetic properties nanomaterials.
CO3	Understand the process and mechanism of synthesis and fabrication of nanomaterials.
CO4	Analyze the various characterization of Nano-products through diffraction, spectroscopic, microscopic and other techniques.
CO5	Apply the concepts of nanoscience and technology in the field of sensors, robotics, purification of air and water and in the energy devices.

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	L	H	L	M
CO2	H	H	L	M	L	H
CO3	H	H	H	H	M	H
CO4	H	M	L	H	L	H
CO5	H	L	M	H	L	H

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	L	M	L	M
CO2	H	H	H	M	M	M
CO3	H	H	L	M	L	M
CO4	H	M	M	H	L	M
CO5	H	M	M	H	L	M

Title of the Course	ELECTIVE V B: ENERGY PHYSICS						
Paper No.	**Generic Elective – IIIB**						
Category	**Elective**	**Year**	II	**Credits**	3	**Course Code**	PEPHJ24
		Semester	III				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Knowledge of conventional energy resources						
Objectives of the course	➢ To learn about various renewable energy sources. ➢ To know the ways of effectively utilizing the oceanic energy. ➢ To study the method of harnessing wind energy and its advantages. ➢ To learn the techniques useful for the conversion of biomass into useful energy. ➢ To know about utilization of solar energy.						
Course Outline	**UNIT I (10 hours) (K1, K2, K3, K4, K5 & K6)** **INTRODUCTION TO ENERGY SOURCES** 1.1 Introduction to Conventional and non-conventional energy sources 1.2 The availability of conventional and non-conventional energy sources 1.3 prospects of Renewable energy sources 1.4 Energy from other sources 1.5 chemical energy–Nuclear energy– 1.6 Energy storage and distribution.						

	UNIT II (8 hours) (K1, K2, K3, K4, K5 & K6)
	ENERGY FROM THE OCEANS
	    2.1 Introduction to energy from oceans
	    2.2 Energy utilization
	    2.3 Energy from tides
	    2.4 Basic principle of tidal power
	    2.5 utilization of tidal energy
	    2.6 Principle of ocean to thermal energy conversion systems.						

	UNIT III (10 hours) (K1, K2, K3, K4, K5 & K6)
	WIND ENERGY SOURCES
	    3.1.Basic principles of wind energy conversion–
	    3.2.power in the wind–
	    3.3.forces in the Blades–
	    3.4.Wind energy conversion–
	    3.5.Advantages and disadvantages of wind energy conversion systems (WECS)
	    3.6.Energy storage–Applications of wind energy.						

	UNIT IV (8 hours) (K1, K2, K3, K4, K5 & K6)
	ENERGY FROM BIOMASS
	    1.1 Biomass Conversion Technologies
	    1.2 Wet and dry process– Photosynthesis
	    1.3 Biogas Generation: Introduction–basic process: Aerobic and anaerobic digestion
	    1.4 Advantages of anaerobic digestion
	    1.5 Factors affecting bio digestion and generation of gas
	    1.6 Bio gas from waste fuel– properties of biogas-utilization of biogas

	UNIT V (9 hours) (K1, K2, K3, K4, K5 & K6)
	SOLAR ENERGY SOURCES
	    5.1.Solar radiation and its measurements–
	    5.2.solar cells: Solar cells for direct conversion of solar energy to electric powers
	    5.3.solar cell parameter–solar cell electrical characteristics
	    5.4.Efficiency–solar water Heater –solar distillation
	    5.5.solar cooking–solar greenhouse
	    5.6.Solar pond and its applications

	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. G.D. Rai, 1996, Non – convention sources of, 4th edition, Khanna publishers, New Delhi. 2. S. Rao and Dr. ParuLekar, Energy technology. 3. M.P. Agarwal, Solar Energy, S. Chand and Co., New Delhi (1983). 4. Solar energy, principles of thermal collection and storage by S.P.Sukhatme, 2ndedition, Tata McGraw-Hill Publishing Co. Lt., New Delhi (1997). 5. Energy Technology by S.Rao and Dr.Parulekar.
Reference Books	1. Renewable energy resources, John Twidell and Tonyweir, Taylor and Francis group, London and New York. 2. Applied solar energy, A.B.MeinelandA.P.Meinal 3. John Twidell and Tony Weir, Renewable energy resources, Taylor and Francis group, London and New York. 4. Renewal Energy Technologies: A Practical Guide for Beginners C.S. Solanki-PHI Learning 5. Introduction to Non-Conventional Energy Resources -Raja et. al., Sci. Tech Publications
Web resources	1.https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=2411&printable=1 2. https://www.nationalgeographic.org/encyclopedia/tidal-energy/ 3. https://www.ge.com/renewableenergy/wind-energy/what-is-wind-energy 4. https://www.reenergyholdings.com/renewable-energy/what-is-biomass/ 5. https://www.acciona.com/renewable-energy/solar-energy/

CO	COURSE OUTCOMES
	At the end of the course, the student will be able to
CO1	To identify various forms of renewable and non-renewable energy sources
CO2	Understand the principle of utilizing the oceanic energy and apply it for practical applications.
CO3	Discuss the working of a windmill and analyze the advantages of wind energy.
CO4	Distinguish aerobic digestion process from anaerobic digestion.
CO5	Understand the components of solar radiation, their measurement and apply them to utilize solar energy.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	M	H	H	M	L	M
CO2	M	H	H	H	H	L
CO3	H	H	H	H	M	L
CO4	M	H	H	M	H	M
CO5	H	H	H	H	M	L

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**
CO1	M	M	H	M	M	M
CO2	M	H	M	H	H	H
CO3	M	H	H	L	L	M
CO4	M	H	H	L	H	H
CO5	M	M	H	H	L	M

Title of the Course	SEC: COMMUNICATION ELECTRONICS						
Paper No.	**SKILL ENHANCEMENT COURSE - II**						
Category	**SEC II**	**Year**	II	**Credits**	2	**Course Code**	PSPH224
		Semester	III				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Knowledge of Regions of electromagnetic spectrum and its characteristics						
Objectives of the course	● To comprehend the transmission of electromagnetic waves thorough different types of antenna and also to acquire knowledge about the propagation of waves through earth's atmosphere and along the surface of the earth ● To gain knowledge in the generation and propagation of microwaves ● To acquire knowledge about radar systems and its applications and also the working principle of colour television ● To learn the working principle of fiber optics and its use in telecommunication ● To understand the general theory and operation of satellite communication systems						
Course Outline	**UNIT I (9 hours) (K1, K2, K3, K4, K5 & K6)** **ANTENNAS AND WAVE PROPAGATION** 1.1. Radiation field and radiation resistance of short dipole antenna- 1.2. Grounded antenna - ungrounded antenna-antenna arrays-broadside and end side arrays 1.3. Antenna gain-directional high frequency antennas 1.4. sky wave-ionosphere- Ecles and Larmor theory 1.5. Magnento ionic theory-ground wave propagation						
	UNIT II (9 hours) (K1, K2, K3, K4, K5 & K6) **MICROWAVES** 2.1. Microwave generation—multicavity Klystron 2.2. Reflex klystron 2.3. Magnetron travelling wave tubes (TWT) and other microwave tubes 2.4. MASER-Gunn diode 2.5. Wave guides- rectangular wave guides 2.6. Standing wave indicator and standing wave ratio (SWR)						

	UNIT III (9 hours) (K1, K2, K3, K4, K5 & K6) **RADAR AND TELEVISION** 3.1. Elements of a radar system-radar equation 3.2. Radar performance Factors radar transmitting systems 3.3. Radar antennas-duplexers-radar receivers and indicators-pulsed systems-other radar systems 3.4. Colour TV transmission and reception- Colour mixing principle- colour picture tubes- 3.5. Delta gun picture tube-PIL Colour picture tube- 3.6. Cable TV, CCTV and theatre TV
	UNIT IV (9 hours) (K1, K2, K3, K4, K5 & K6) **OPTICAL FIBER** 4.1. Propagation of light in an optical fibre 4.2. Acceptance angle-numerical aperture 4.3. Step and graded index fibres 4.4. Optical fibres as a cylindrical waveguide- 4.5. Wave guide equations-wave guide equations in step index fibres 4.6. Fibre losses and dispersion- applications
	UNIT V (9 hours) (K1, K2, K3, K4, K5 & K6) **SATELLITE COMMUNICATION** 5.1. Orbital satellites-geostationary satellites 5.2. Orbital patterns-satellite system link models 5.3. Satellite system parameters 5.4. Satellite system link equation link budget 5.5. INSAT communication satellites
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. Handbook of Electronics by Gupta and Kumar, 2008 edition. 2. Electronic communication systems – George Kennedy and Davis, Tata McGraw Hill, 4th edition, 1988. 3. Taub and Schilling, principles of communication systems, second edition, Tata Mc Graw Hill (1991). 4. M. Kulkarani, Microwave and radar engineering, Umesh Publications, 1998. 5. Mono Chrome and colour television, R. R. Ghulathi

Reference Books	1. Electronic communications – Dennis Roody and Coolen, Prentice Hall of India, IV edition, 1995. 2. Wayne Tomasi, Advanced electronics communication systems, fourth edition, Prentice Hall of India, 1998 3. Dennis Roddy and Coolen,1995, Electronics communications, Prentice Hall of India IV Edition. 4. Wayne Tomasi,1998 "Advanced Electronics communication System" 4thedition, Prentice Hall of India, 1998 5. S. Salivahanan, N. Suersh Kumar & A. Vallavaraj, 2009, Electronic Devices and Circuits, Tata McGraw-Hill Publishing Company Limited, New Delhi, Second Edition.
Web resources	1. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/ 2. https://www.polytechnichub.com/difference-analog-instruments-digital-instruments/ 3. http://nptel.iitm.ac.in/ 4. http://web.ewu.edu/ 5. http://nptel.iitm.ac.in/

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Discuss and compare the propagation of electromagnetic waves through sky and on earth's surface Evaluate the energy and power radiated by the different types of antenna
CO2	Compare and differentiate the methods of generation of microwaves analyze the propagation of microwaves through wave guides- discuss and compare the different methods of generation of microwaves
CO3	Classify and compare the working of different radar systems- apply the principle of radar in detecting locating, tracking, and recognizing objects of various kinds at considerable distances – discuss the importance of radar in military- elaborate and compare the working of different picture tube
CO4	Classify, discuss and compare the different types of optical fiber and also to justify the need of it-discover the use of optical fiber as wave guide
CO5	Explain the importance of satellite communication in our daily life-distinguish between orbital and geostationary satellites elaborate the linking of satellites with ground station on the earth

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	L	M	M
CO2	H	H	H	L	M	M
CO3	H	H	H	M	M	M
CO4	H	H	H	L	M	M
CO5	H	H	H	L	M	M

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	L	M	M
CO2	H	H	H	L	M	M
CO3	H	H	H	L	M	M
CO4	H	H	H	L	M	M
CO5	H	H	H	L	M	M

Title of the Course	SPECTROSCOPY						
Paper No.	Core XIII						
Category	Core	Year	II	Credits	4	Course Code	PCPHM24
		Semester	IV				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	6	-		-		5	
Pre-Requisites	Thorough understanding of electromagnetic spectrum, mathematical abilities, knowledge of molecules, their structure, bond nature, physical and chemical behavior						
Objectives of the course	• To comprehend the theory behind different spectroscopic methods • To know the working principles along with an overview of construction of different types of spectrometers involved • To explore various applications of these techniques in R &D. • Apply spectroscopic techniques for the qualitative and quantitative analysis of various chemical compounds. • Understand this important analytical tool						
Course Outline	**UNIT I: (18 Hours) (K1, K2, K3, K4, K5)** **MICROWAVE SPECTROSCOPY** 1.1 Rotational spectra of diatomic molecules - Rigid Rotor (Diatomic Molecules)-reduced mass – rotational constant – 1.2 Effect of isotopic substitution - Non rigid rotator – centrifugal distortion constant- Intensity of Spectral Lines 1.3 Polyatomic molecules – linear – symmetric asymmetric top molecules – 1.4 Hyperfine structure and quadruple moment of linear molecules - Stark effect 1.5 Instrumentation techniques – block diagram 1.6 Information Derived from Rotational Spectra-						
	UNIT II:(18 Hours) (K1, K2, K3, K4, K5 & K6) **INFRA-RED SPECTROSCOPY** 2.1 Vibrations of simple harmonic oscillator – zero-point energy- Anharmonic oscillator – fundamentals, overtones and combinations 2.2 Diatomic Vibrating Rotator- PR branch – PQR branch 2.3 Fundamental modes of vibration of H_2O and CO_2 2.4 Introduction to application of vibrational spectra 2.5 IR Spectrophotometer Instrumentation (Double Beam Spectrometer) – Fourier Transform Infrared Spectroscopy 2.6 Interpretation of vibrational spectra– remote analysis of atmospheric gases like N2O using FTIR by National Remote Sensing Centre (NRSC), India– other simple applications						
	UNIT III: (18 Hours) (K1, K2, K3, K4, K5 & K6) **RAMAN SPECTROSCOPY** 3.1 Theory of Raman Scattering - Classical theory – molecular polarizability – polarizability ellipsoid - Quantum theory of Raman effect 3.2 rotational Raman spectra of linear molecule - symmetric top molecule –						

	Stokes and anti-stokes line- SR branch 3.3 Raman activity of H_2O and CO_2 -Mutual exclusion principle- determination of N_2O structure 3.4 3.4-Instrumentation technique and block diagram 3.5 structure determination of planar and non-planar molecules using IR and Raman techniques - FT Raman spectroscopy- SERS 3.6 Raman effect in relation to inorganic, organic and physical chemistry
	UNIT IV: (18 Hours) (K1, K2, K3, K4, K5 & K6) **RESONANCE SPECTROSCOPY** 4.1 Nuclear and Electron spin-Interaction with magnetic field - Population of Energy levels - Larmor precession- Relaxation times 4.2 Double resonance- Chemical shift and its measurement - NMR of Hydrogen nuclei - Indirect Spin -Spin Interaction – 4.3 interpretation of simple organic molecules - Instrumentation techniques of NMR spectroscopy – NMR in Chemical industries- MRI Scan 4.4 Electron Spin Resonance: Basic principle –Total Hamiltonian (Direct Dipole-Dipole interaction and Fermi Contact Interaction) – 4.5 Hyperfine Structure (Hydrogen atom) – ESR Spectra of Free radicals 4.6 g-factors – Instrumentation - Medical applications of ESR
	UNIT V: (18 Hours) (K1, K2, K3, K4, K5 & K6) **UV SPECTROSCOPY** 5.1 Origin of UV spectra – Principles of absorption spectroscopy – Beer - Lambert – Bouguer's law – Lambert - Beer's law - molar absorptivity - -–transmittance and absorbance 5.2 Color in organic compounds - Chromophores - Absorption by organic Molecule 5.3 Effect of conjugation on chromophores - Choice of Solvent and Solvent effect 5.4 Absorption by inorganic systems 5.5 Instrumentation - double beam UV-Spectrophotometer 5.6 Simple applications
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Text Books	1. C N Banwell and E M McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw–Hill, New Delhi. 2. G Aruldhas, 1994, Molecular Structure and Molecular Spectroscopy, Prentice–Hall of India, New Delhi. 3. D.N. Satyanarayana, 2001, *Vibrational Spectroscopy and Applications*, New Age International Publication. 4. B.K. Sharma, 2015, *Spectroscopy*, Goel Publishing House Meerut. 5. Kalsi.P.S, 2016, Spectroscopy of Organic Compounds (7th Edition), New Age International Publishers. 6. Pavia, Lampman, Kriz and Vyvyan, spectroscopy, cengage learning, 2008
Reference Books	1. J L McHale, 2008, Molecular Spectroscopy, Pearson Education India, New Delhi.

	2. J M Hollas, 2002, Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry, RSC, Cambridge.
	3. B. P. Straughan and S. Walker, 1976, Spectroscopy Vol. I, Chapman and Hall, New York.
	4. K. Chandra, 1989, Introductory Quantum Chemistry, Tata McGraw Hill, New Delhi.
	5. Demtroder. W, Laser Spectroscopy: Basic concepts and Instrumentation, SpringerLink.
Web resources	1. https://www.youtube.com/watch?v=0iQhirTf2PI
	2. https://www.coursera.org/lecture/spectroscopy/introduction-3N5D5
	3. https://www.coursera.org/lecture/spectroscopy/infrared-spectroscopy-8jEee
	4. https://onlinecourses.nptel.ac.in/noc20_cy08/preview
	5. https://www.coursera.org/lecture/spectroscopy/nmr-spectroscopy-introduction-XCWRu

CO	COURSE OUTCOMES
	At the end of the course the student will be able to:
CO1	Understand fundamentals of rotational spectroscopy, view molecules as elastic rotors and interpret their behaviour. Able to quantify their nature and correlate them with their characteristic properties.
CO2	Understand the working principles of spectroscopic instruments and theoretical background of IR spectroscopy. Able to correlate mathematical process of Fourier transformations with instrumentation. Able to interpret vibrational spectrum of small molecules.
CO3	Interpret structures and composition of molecules and use their knowledge of Raman Spectroscopy as an important analytical tool
CO4	Use these resonance spectroscopic techniques for quantitative and qualitative estimation of a substances
CO5	Learn the electronic transitions caused by absorption of radiation in the UV/Vis region of the electromagnetic spectrum and be able to analyze a simple UV spectrum.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	M	H	H
CO2	M	M	M	H	H	H
CO3	H	M	H	H	H	H
CO4	H	M	H	H	H	H
CO5	H	H	H	H	H	H

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	M	H	H
CO2	M	M	M	H	H	H
CO3	H	M	H	H	H	H
CO4	H	M	H	H	H	H
CO5	H	H	H	H	H	H

Title of the Course	NUCLEAR AND PARTICLE PHYSICS						
Paper No.	Core XIV						
Category	Core	**Year**	II	Credits	4	Course Code	PCPHN24
		Semester	IV				
Instructional hours per week	Lecture	Tutorial		Lab Practice		Total	
	5	-		-		5	
Pre-Requisites	Knowledge of basic structure of atom and nucleus.						
Objectives of the course	- Introduces students to the different models of the nucleus in a chronological order - Imparts an in-depth knowledge on the nuclear force, experiments to study it and the types of nuclear reactions and their principles - Provides students with details of nuclear decay with relevant theories - Exposes students to the Standard Model of Elementary Particles and Higgs boson						
Course Outline	**UNIT I (16 hours) (K1, K2, K3, K4 & K5)** **NUCLEAR FORCES** 1.1 Introduction - Nuclear forces - Two body problem 1.2 Ground state of deuteron - Magnetic moment - Quadrupole moment - Tensor forces 1.3 Meson theory of nuclear forces - Yukawa potential 1.4 Nucleon - Nucleon scattering - Low energy n-p scattering 1.5 Effective range theory - Spin dependence 1.6 Charge independence and charge symmetry of nuclear forces-Isospin formalism.						
	UNIT II (15 hours) (K1, K2, K3, K4, K5 & K6) **NUCLEAR REACTIONS** 2.1 Types of reactions and conservation laws 2.2 Energetic of nuclear reactions –Dynamics of nuclear reactions - Q-value equation 2.3 Partial wave analysis of Scattering and reaction cross sections 2.4 Compound nuclear reactions - Reciprocity theorem 2.5 Breit - Wigner one level formula - Resonance scattering 2.6 Continuum theory - Optical model						
	UNIT III (16 hours) (K1, K2, K3, K4 & K5) **NUCLEAR MODELS**						

	3.1 Introduction - Liquid drop model (K2, K3, K4) 3.2 Semi empirical mass formula of Weizsacker - Nuclear stability- Mass parabolas 3.3 Bohr-Wheeler theory of fission 3.4 Shell model - Spin-orbit coupling - Magic numbers 3.5 Angular momenta and parities of nuclear ground states -Problems 3.6 Collective model of Bohr and Mottelson- rotational and vibrational bands.
	UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6) **NUCLEAR DECAY** 4.1 Beta decay - Fermi theory of beta decay - Fermi - Curie Plo 4.2 Fermi and Gamow- Tellar selection rules - Allowed and forbidden decays - Decay rates 4.3 Neutrino physics – Helicity - Parity violation 4.4 Theory of electron capture 4.5 Gamma decay – multipole radiations – Angular Correlation - internal conversion 4.6 Nuclear isomerism – angular momentum and parity selection rules.
	UNIT V (16 hours) (K1, K2, K3, K4, K5 & K6) **ELEMENTARY PARTICLES** 5.1 Classification of Elementary Particles – Based on spins 5.2 Types of Interaction and conservation laws – Families of elementary particles 5.3 Quantum numbers and conservation laws - Isospin – Strangeness – Hypercharge 5.4 Classification of hadrons - SU(2) and SU(3) multiplets - Quarks –SU (2) and SU (3) groups 5.5 Quark Model - Gell Mann matrices– Gell Mann Okuba Mass formulafor octet and decupled hadrons. 5.6 Standard model of particle physics – Higgs boson.
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. D. C. Tayal – Nuclear Physics – Himalaya Publishing House (2011) 2. M.L. Pandya and R.P.S. Yadav - Elements of Nuclear Physics, 7th Edition, KedarNath Ram Nath, Delhi, 1995. 3. S.N. Ghoshal - Atomic and Nuclear Physics, Vol. 2 - S Chand & Co. Ltd., 2000. 4. V.Devanathan - Nuclear Physics, 2nd Edition - Narosa Publication, 2011. 5. S. Glasstone – Source Book of Atomic Energy – Van Nostrand Reinhold Inc.,U.S.- 3rd Revised edition (1968)

Reference Books	1. L. J. Tassie – The Physics of elementary particles – Prentice Hall Press (1973)
	2. H. A. Enge – Introduction to Nuclear Physics – Addison Wesley, Publishing Company. Inc. Reading. New York, (1974).
	3. Kaplan – Nuclear Physics – 1989 – 2nd Ed. – Narosa (2002)
	4. Bernard L Cohen – Concepts of Nuclear Physics – McGraw Hill Education (India) Private Limited; 1 edition (2001)
	5. B.L. Cohen, 1971, Concepts of Nuclear Physics, TMCH, New Delhi.
Web resources	1. http://bubl.ac.uk/link/n/nuclearphysics.html
	2. http://www.phys.unsw.edu.au/PHYS3050/pdf/Nuclear_Models.pdfhttp://www.scholarpedia.org/article/Nuclear_Forces
	3. https://www.nuclear-power.net/nuclear-power/nuclear-reactions/
	4. http://labman.phys.utk.edu/phys222core/modules/m12/nuclear_models.html
	5. https://www.ndeed.org/EducationResources/HighSchool/Radiography/radioactivedecay.html

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Gain knowledge of architecture and working of 8085 microprocessors.
CO2	Get knowledge of architecture and working of 8051 Microcontroller.
CO3	Be able to write simple assembly language programs for 8085A microprocessor.
CO4	Able to write simple assembly language programs for 8051 Microcontroller.
CO5	Understand the different applications of microprocessors and microcontrollers.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	M	M	M
CO2	H	H	M	H	M	M
CO3	H	M	L	L	M	M
CO4	H	H	M	M	M	M
CO5	H	H	M	H	M	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	M	H	M	H	M
CO2	H	M	L	H	H	M
CO3	H	M	L	L	M	M
CO4	H	L	M	M	M	M
CO5	H	M	M	H	H	M

Title of the Course	**PRACTICAL -IV - NUMERICAL METHODS AND COMPUTER PROGRAMMING (FORTRAN/C)**						
Paper No.	**Core XV**						
Category	**Core**	**Year**	II	**Credits**	3	**Course Code**	PCPHO24
		Semester	IV				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
		-		6		4	
Pre-Requisites	Basic knowledge in differential equation and linear algebra Basic knowledge of operating system and computer fundamentals.						
Objectives of the course	● The aim and objective of the course on Computational Practical is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using any high level language such as C ● To equip the computational skill using various mathematical toolsTo apply the software tools to explore the concepts of physical science. ● To understand the theory and working of Microprocessor, Microcontroller and their applications ● To use microprocessor and Microcontroller in different applications						
Course Outline	**(Minimum of Twelve Experiments from the list)** 1. Lagrange interpolation with Algorithm, Flow chart and output. 2. Newton forward interpolation with Algorithm, Flow chart and output. 3. Newton backward interpolation with Algorithm, Flow chart and output. 4. Curve-fitting: Least squares fitting with Algorithm, Flow chart and output. 5. Numerical solution of ordinary first-order differential equations by the Euler method with Algorithm, Flow chart and output. 6. Numerical solution of ordinary first-order differential equations by the Runge- Kutta method with Algorithm, Flow chart and output. 7. Finding Roots of a Polynomial - Bisection Method – 8. Finding Roots of a Polynomial - Newton Raphson Method – 9. Solution of Simultaneous Linear Equation by Gauss elimination method. 10. Newton's cotes formula 11. Trapezoidal rule 12. Simpson's 1/3 rule 13. Simpson's 3/8 rule 14. 8-bit addition and subtraction, multiplication and division using						

	microprocessor 8085
	15. Sum of a set of N data (8-bit number), picking up the smallest and largest number in an array. Sorting in ascending and descending order using microprocessor 8085
	16. Code conversion (8-bit number): a) Binary to BCD vice versa b) ASCII to binary vice versa using microprocessor 8085
	17. Clock program- 12/24 hours-Real time application – Six Digits Hexa Decimal and Decimal Counters using microprocessor 8085
	18. Interfacing of seven segment display using microprocessor 8085
	19. Wave form generation – Square, Rectangular, Triangular, Saw tooth and Sine waves using microprocessor 8085
	20. Interfacing of DC stepper motor – Clockwise, Anti-clockwise, Angular movement and Wiper action using microprocessor 8085
	21. Interfacing of Traffic light controller using microprocessor 8085
	22. 8-bit addition and subtraction, multiplication and division using 8051 microcontroller
	23. Sorting in ascending and descending order, Sorting out the maxima and minima using 8051 microcontroller
Textbooks	1. M.K. Jain, S.R. Iyengar and R.K. Jain, 1995, Numerical Methods for Scientific and Engineering Computation, 3rd Ed. New Age International, New Delhi. 2. Advanced Practical Physics, 2024, Reena Devi, Mary Jamila, Bharathi Book House Publication. 3. Numerical methods in Science and Engineering - M.K. Venkataraman, National Publishing Co. Madras, 1996 4. V. Rajaraman, 1993, Computer Oriented Numerical Methods, 3rd Ed. (Prentice-Hall, New Delhi. 5. V. Vijayendran, 2005, Fundamentals of Microprocessor-8085", 3rd Edition S.Visvanathan Pvt, Ltd.
Reference Books	1. S.D. Conte and C. de Boor, 1981, Elementary Numerical Analysis, An Algorithmic Approach, 3rd Ed., International Ed. (McGraw-Hill). 2. B.F. Gerald and P.O. Wheately, 1994, Applied Numerical Analysis, 5th Edition, Addison Wesley, Reading, MA. 3. B. Carnahan, H.A. Luther and J.O. Wikes, 1969, Applied Numerical Methods (Wiley, New York. 4. S.S. Kuo, 1996, Numerical Methods and Computers, Addison - Wesley, London. 5. V. Rajaraman,Programming in FORTRAN/ Programming in C, PHI, New Delhi.

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Program with the C Program/ FORTRAN with the C or any other high level language
CO2	Use various numerical methods in describing/solving physics problems.
CO3	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.
CO4	To enhance the problem-solving aptitudes of students using various numerical methods.
CO5	Understand the structure and working of 8085 microprocessor and 8051 microcontroller and apply it and acquire knowledge about the interfacing peripherals with 8085 microprocessor and 8051 microcontroller

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	H	H	L
CO2	M	L	L	L	L	L
CO3	M	H	H	H	H	L
CO4	M	H	H	H	H	L
CO5	M	H	H	H	H	L

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	H	H	H	H	L
CO2	M	L	L	L	L	L
CO3	H	H	H	H	H	L
CO4	H	H	H	H	H	L
CO5	H	H	H	H	H	L

Title of the Course	ELECTIVE VI A: MICROPROCESSOR 8085 AND MICROCONTROLLER 8051						
Paper No.	**Elective VI**						
Category	**Elective**	**Year**	II	**Credits**	3	**Course Code**	PEPHK24
		Semester	IV				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	3	-		-		3	
Pre-Requisites	Knowledge of number systems and binary operations						
Objectives of the course	● To provide an understanding of the architecture and functioning of microprocessor 8085A and to the methods of interfacing I/O devices and memory to microprocessor ● To introduce 8085A programming and applications and the architecture and instruction sets of microcontroller 8051						
Course Outline	**UNIT I (16 hours) (K1, K2, K3, K4 & K5)** **8085 PROGRAMMING, PERIPHERAL DEVICES AND THEIR INTERFACING** 1.1 Instruction set 1.2 Addressing modes 1.3 Memory mapped I/O scheme- I/O mapped I/O scheme - Memory and I/O interfacing- 1.4 Data transfer schemes - Interrupts of 8085 – 1.5 Programmable peripheral interface (8255PPI) - Control group and control word 1.6 Programmable DMA controller - Programmable interrupt controller – Programmable communication interface - Programmable counter /interval timer.						
	UNIT II (15 hours) (K1, K2, K3, K4, K5 & K6) **8085 INTERFACING APPLICATIONS** 2.1 Seven segment display interface – Keyboard Interface 2.2 Interfacing of Digital to Analog converter and 2.3 Analog to Digital converter 2.4 Stepper motor interface 2.5 Measurement of electrical quantities –Voltage and current) 2.6 Measurement of physical quantities (Temperature and strain).						

	UNIT III (16 hours) (K1, K2, K3, K4 & K5) **8051 MICROCONTROLLER HARDWARE** 3.1　Introduction – Features of 8051 3.2　8051 Microcontroller Hardware: Pin-out 8051, Central Processing Unit (CPU), 3.3　internal RAM, Internal ROM, 3.4　Register set of 8051 3.5　Memory organization of 8051 3.6　Input/Output pins, Ports and Circuits – External data memory and program memory.
	UNIT IV (15 hours) (K1, K2, K3, K4, K5 & K6) **8051 INSTRUCTION SET AND ASSEMBLY LANGUAGE** **PROGRAMMING** 4.1 Addressing modes – Data moving (Data transfer) instructions: 4.2 Instructions to Access external data memory, external ROM / program memory, 4.3 PUSH and POP instructions, Data exchange instructions – Logical instructions: byte and bit level logical operations, 4.4 Rotate and swap operations – Arithmetic instructions: Flags, Incrementing and decrementing, Addition, Subtraction, Multiplication and division, Decimal arithmetic – 4.5 Jump and CALL instructions: Jump and Call program range, 4.6 Jump, Call and subroutines – Programming.
	UNIT V (16 hours) (K1, K2, K3, K4, K5 & K6) **INTERRUPT PROGRAMMING AND INTERFACING TO EXTERNAL** **WORLD** 5.1　8051 Interrupts – Interrupt vector table – Enabling and disabling an interrupt 5.2　Timer interrupts and programming – Programming external hardware interrupts Serial communication interrupts and programming 5.3　Interrupt priority in the 8051 : Nested interrupts 5.4　Software triggering of interrupt. LED Interface Seven segment display interface- 5.5　Interfacing of Digital to Analog converter and Analog to Digital converter 5.6　Stepper motor interface - Measurement of electrical quantities – Voltage and current) Measurement of physical quantities(Temperature an strain).
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

Textbooks	1. A. Nagoor Kani, Microprocessors & Microcontrollers, RBA Publications (2009). 2. A. P. Godse and D. A. Godse, Microprocessors, Technical Publications, Pune (2009). 3. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with 8085, Penram International Publishing (2013). 4. B. Ram, Fundamentals of Microprocessors & Microcontrollers, DhanpatRai publications New Delhi (2016). 5. V. Vijayendran, 2005, Fundamentals of Microprocessor-8085", 3rd Edition S.Visvanathan Pvt, Ltd.
Reference Books	1. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware, Tata Mc Graw Hill Publications (2008) 2. Muhammad Ali Mazidi, Janice GillispieMazidi, Rolin D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson Education (2008). 3. Barry B. Brey, 1995, The Intel Microprocessors 8086/8088, 80186, 80286, 80386 and 80486, 3rd Edition, Prentice- Hall of India, New Delhi. 4. J. Uffrenbeck, "The 8086/8088 Family-Design, Programming and Interfacing, Software, Hardware and Applications", Prentice-Hall of India, New Delhi. 5. W. A. Tribel, Avtar Singh, "The 8086/8088 Microprocessors: Programming, Interfacing, Software, Hardware and Applications", Prentice-Hall of India, New Delhi.
Web resources	1. https://www.tutorialspoint.com/microprocessor/microprocessor_8085_architecture.html 2. http://www.electronicsengineering.nbcafe.in/peripheral-mapped-io-interfacing/ 3. https://www.geeksforgeeks.org/programmable-peripheral-interface-8255/ 4. http://www.circuitstoday.com/8051-microcontroller 5. https://www.elprocus.com/8051-assembly-language-programming/

CO	Course Outcomes
On completion of this course, students will be able to;	
CO1	Gain knowledge of architecture and working of 8085 microprocessors.
CO2	Get knowledge of architecture and working of 8051 Microcontroller.
CO3	Be able to write simple assembly language programs for 8085A microprocessor.
CO4	Able to write simple assembly language programs for 8051 Microcontroller.
CO5	Understand the different applications of microprocessors and microcontrollers.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	H	H	L
CO2	M	L	L	L	L	L
CO3	H	H	H	H	H	L
CO4	H	H	H	H	H	L
CO5	H	H	H	H	H	L

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	H	H	H	H	L
CO2	M	L	L	L	L	L
CO3	H	H	H	H	H	L
CO4	H	H	H	H	H	L
CO5	H	H	H	H	H	L

Title of the Course	ELECTIVE VI B: MEDICAL PHYSICS						
Paper No.	Elective						
Category	Elective	Year	II	Credits	2	Course Code	PEPHL24
		Semester	IV				
Instructional hours per week	Lecture	Tutorial	Lab Practice	Total			
	4	-	-	4			
Pre-Requisites	Fundamentals of physiological concepts, Basics of instruments principle,						
Objectives of the course	• To understand the major applications of Physics to Medicine • To study the aid of different medical devices such as X-ray machines, gamma camera, accelerator and nuclear magnetic resonance. • To outline the principles of Physics of different medical radiation devices and their modern advances, especially in medical radiation therapy and different applications in medical physics. • To introduce the ideas of Radiography. • To form a good base for further studies like research.						
Course Outline	**UNIT I (12 hours) (K1, K2, K3 & K4)** **EFFECTS OF PRESSURE ON HUMAN SYSTEM** 1.1. Measurement of pressure in the human body 1.2. Pressure inside the skull 1.3. Transillumination - eye pressure - tonometers- ophthalmoscopy 1.4. Pressure in the digestive system - urinary bladder 1.5. Pressure in the skeletal system - stress and strain - strain gage 1.6. Transducers for biomedical applications						
	UNIT II (12 hours) (K1, K2, K3 & K4) **PHYSICS OF LUNGS AND BREATHING** 2.1 The airways - interaction of the blood and the lungs 2.2 Measurement of pulmonary volume - volume relationships of the lungs 2.3 Physics of alveoli - breathing mechanism 2.4 Pulmonary flow - pulmonary diffusion - airway resistance - measurement of airway resistance 2.5 Work done in breathing - measurement of gaseous exchange and diffusion 2.6 Respiratory therapy equipment - physics of some common long disease						
	UNIT III (12 hours) (K1, K2, K3 & K4) **PHYSICS OF CARDIOVASCULAR SYSTEMS** 3.1. The heart and cardiovascular system 3.2. Oxygen and CO_2 exchange - work done by heart 3.3. Pressure across the blood vessel - characteristics of blood flow - heart sounds 3.4. Blood pressure measurement - indirect measurements - direct measurements 3.5. Percutaneous insertion - catheterization implantation of transducer - measurement of blood flow and cardiac output 3.6. Elements of intensive care monitoring - pacemakers - defibrillators						

	UNIT IV (12 hours) (K1, K2, K3 & K4) **APPLICATION OF ELECTRICITY AND MAGNETISM IN MEDICINE** 4.1 The nervous system and neurons 4.2 Source of bioelectric potentials - testing and action potentials 4.3 Propagation of action potentials - electrodes - theory 4.4 Biopotential electrodes electromyogram-electrocardiogram - electroencephalogram 4.5 Magneto cardiogram - thermography and skin temperature measurements 4.6 Applications of high and frequency electricity in medicine
	UNIT V (12 hours) (K1, K2, K3 & K4) **MEDICAL IMAGING TECHNIQUES** 5.1 X-rays and radio isotopes - instrumentation - X-rays in diagnosis 5.2 Medical application of radioisotopes - radiation therapy 5.3 Principles of ultrasonic measurement - ultrasonic diagnosis 5.4 Magnetic Resonance Imaging (MRI) - Computerized Axial Tomography scanner (CAT) 5.5 Positron Emission Tomography (PET) imaging 5.6 Physiological effects of electric current - shock hazards - methods of accident prevention
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. J.R. Cameron and James G. Skofronick - Medical Physics - John Wiley & Sons Inc. 1978. 2. A.C. Damask - Medical Physics Vol I & II - Academic press 1978, 1981. 3. John G. Webster - Bioinstrumentation - John Wiley & Sons, Inc. 2003. 4. Leslie Cromwell, Fred. J. Weibell Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India Pvt., Ltd., 2007. 5. M. Arumugam - Biomedical Instrumentation - Anuradha publications, 2007.
Reference Books	1. W. Hoppe et al. - Biophysics - Springer - Verlag 1983. 2. A.J. Vander, J.H. Sherman and D.S. Lucian - Human Physiology, McGraw – Hill (International Ed.,), 1986.
Web resources	1. https:nptel.ac.in/courses/108/103/108103157/ 2. https://www.studocu.com/en/course/university-of-technology-sydney/medical-devices-and-diagnostics/225692 3. https://www.technicalsymposium.com/alllecturenotes_biomed.html 4. https://lecturenotes.in/notes/17929-note-for-biomedical-instrumentation-bi-by-deepraj-adhikary/78 5. https://www.modulight.com/applications-medical/

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Learn the fundamentals, production and applications of X-rays.
CO2	Understand the basics of blood pressure measurements. Learn about sphygmomanometer, EGC, ENG and basic principles of MRI.
CO3	Apply knowledge on Radiation Physics
CO4	Analyze Radiological imaging and filters
CO5	Assess the principles of radiation protection

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	L	L	M
CO2	H	H	H	M	L	M
CO3	H	H	H	M	L	M
CO4	H	H	H	M	L	M
CO5	H	H	H	L	L	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	H	H	H	L	L	M
CO2	H	H	H	M	L	M
CO3	H	H	H	M	L	M
CO4	H	H	H	M	L	M
CO5	H	H	H	L	L	M

Title of the Course	SOLID WASTE MANAGEMENT						
Paper No.	**Professional Competency Skill**						
Category	**Elective**	**Year**	II	**Credits**	3	**Course Code**	PPPH24
		Semester	IV				
Instructional hours per week	**Lecture**	**Tutorial**		**Lab Practice**		**Total**	
	1	-		2		3	
Pre-Requisites	Basic knowledge of solid waste and its type						
Objectives of sthe course	● To gain basic knowledge in solid waste management procedures ● To gain industry exposure and be equipped to take up a job. ● To harness entrepreneurial skills. ● To analyze the status of solid waste management in the nearby areas. ● To sensitize the importance of healthy practices in waste managements						
Course Outline	**UNIT I (5 hours) (K1, K2, K3, K4 & K5)** **SOLID WASTE MANAGEMENT** 1.1 Introduction – Definition of solid waste 1.2 Different Types 1.3 Hazardous Waste: Resource conservation 1.4 Renewal act 1.5 Hazardous Waste: Municipal Solid waste 1.6 Non-municipal solid waste.						
	UNIT II (5 hours) (K1, K2, K3, K4, K5 & K6) **SOLID WASTE CHARACTERISTICS** 2.1 Introduction to Solid waste characteristics 2.2 Solid Waste Characteristics 2.3 Physical characteristics of solid waste 2.4 Chemical characteristics of solid waste 2.5 SWM hierarchy factors affecting SW generation 2.6 SWM affecting characteristics						
	UNIT III (5 hours) (K1, K2, K3, K4 & K5) **TOOLS AND EQUIPMENT** 3.1 Introduction to Tools and Equipment 3.2 Tools and Equipment 3.3 Transportation 3.4 Disposal technique						

	3.5 Composting technique 3.6 land filling technique
	UNIT IV (10 hours) (K1, K2, K3, K4, K5 & K6) **ECONOMIC DEVELOPMENT** 4.1 SWM for economic development and 4.2 environmental protection 4.3 Linking SWM and climate change and marine litter. 4.4 SWM Industrial visit 4.5 Data collection 4.6 Analysis of data
	UNIT V (20 hours) (K1, K2, K3, K4, K5 & K6) **INDUSTRIAL VISIT** Project- presentation
	PROFESSIONAL COMPONENTS Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
Textbooks	1. Handbook of Solid Waste Management /Second Edition, George Tchobanoglous, McGraw Hill (2002). 2. Prospects and Perspectives of Solid Waste Management, Prof. B BHosett, New Age International (P) Ltd (2006). 3. Solid and Hazardous Waste Management, Second Edition, M.N Rao, BS Publications / BSP Books (2020). 4. Integrated Solid Waste Management Engineering Principles and Management, Tchobanoglous, McGraw Hill (2014). 5. Solid Waste Management (SWM), Vasudevan Rajaram, PHI learning private limited, 2016
Reference Books	1. Municipal Solid Waste Management, Christian Ludwig, Samuel Stucki, Stefanie Hellweg, Springer Berlin Heisenberg, 2012 2. Solid Waste Management Bhide A. D Indian National Scientific Documentation Centre, New Delhi Edition 1983 ASIN: B0018MZ0C2 3. Solid Waste Techobanoglous George; Kreith, Frank McGraw Hill Publication, New Delhi 2002, ISBN 9780071356237 4. Environmental Studies Manjunath D. L. Pearson Education Publication, New Delhi, 20061SBN-I3: 978-8131709122 5. Solid Waste Management Sasikumar K. PHI learning, New Delhi, 2009 ISBN 8120338693

Web resources	1. https://www.meripustak.com/Integrated-Solid-Waste-Management-Engineering-Principles-And-Management-Issues-125648 2. https://testbook.com/learn/environmental-engineering-solid-waste-management/ 3. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsA-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJ_jxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 4. https://images.app.goo.gl/tYiW2gUPfS2cxdD28 https://amzn.eu/d/5VUSTDI

CO	Course Outcomes
	On completion of this course, students will be able to;
CO1	Gained knowledge in solid waste management
CO2	Equipped to take up related job by gaining industry exposure
CO3	Develop entrepreneurial skills
CO4	Will be able to analyze and manage the status of the solid wastes in the nearby areas
CO5	Adequately sensitized in managing solid wastes in and around his/her locality

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	H	M	M
CO2	M	H	H	M	M	M
CO3	M	H	M	M	M	M
CO4	H	M	M	M	M	H
CO5	M	H	H	M	M	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	M	H	H	H	M	M
CO2	M	H	H	H	M	M
CO3	M	H	M	MS	M	M
CO4	H	M	M	M	M	H
CO5	M	H	H	M	M	M