KAMARAJ COLLEGE

(AUTONOMOUS)

Accredited with A+ Grade by NAAC

Among Top 150 Colleges in India - NIRF Ranking 2025

இந்து நாடார் சங்கங்களால் 1966-ல் தொடங்கப்பட்ட கல்லூரி

(Affiliated to Manonmaniam Sundaranar University, Tirunelveli)

THOOTHUKUDI - 628 003.

M.Sc., Physics

Semester – I to IV

(for the students those who joined from the academic year 2024-2025)

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SYLLABUS

(for the students those who joined from the academic year 2024-2025)

Department Profile

The Programme : M. Sc., - Physics

Programme Code 07033

Year of Establishment : 2022-2023

E- MAIL ID : kamarajcollegephysics@gmail.com

Vision

- To provide a strong foundation for students perusing physics for their excellence with well-behaved personality, academics and global vision.

Mission

- To produce nationally competent and quality graduate by educating the concept of Physics and Techniques
- To facilitate the students to work with recent tools and techniques
- To mould the students by inculcating the spiral of ethical values contributing to the social ethic.

College Mail ID :

kamarajcoll@gmail.com College Website

:

https://kamarajcollege.ac.in

Postgraduate Degree Programme

1. Introduction

Programme Outcome, Programme Specific Outcomes and Course Outcomes Students completing this programme will be able to present their core under-graduate discipline clearly and precisely, make abstract ideas precise by formulating them in the language of the specific discipline, describe related ideas from multiple perspectives and explain fundamental concepts. Completion of this programme will also enable the learners to join teaching profession, enhance their employability for government jobs, jobs in various other public and private enterprises

Eligibility:

Candidates shall be admitted to the course provided if he / she has obtained a bachelor's degree in science in Physics.

Internship

To strengthen and elevate the professional skills of students, Internship (Part Time / Full Time) is incorporated with 2 credits (3 Hours / Cycle) in Third semester. An Internship for a minimum of 45 hours should be completed by every student.

Evaluation

Student shall submit their report (10 pages focusing internship, excluding front page, declaration, certificate etc.,) individually. The evaluation will be done at the end of the Third semester by both external and internal examiners for a maximum marks of 100.

Industrial and Institutional Visit/ Extension Activity

To give exposure about scope and developments in the field of Physics for students, Industrial / Institutional visits is included in the third semester with 2 credit (2 Hours / Cycle). It helps the students to make themselves aware of the demands in the fields, expectations of the concerned and the qualifications to be developed in them. Understanding the societal needs, current status and market potential will explore the possibilities of becoming an entrepreneur. Staff accompanying the students should be given non-remunerative OD for such visits.

Evaluation

Student shall submit their report (10 pages focusing Industrial and Institutional, excluding front page, declaration, certificate etc.,) possibly with geo- taged photography. The evaluation will be done at the end of third semester by both external and internal examiners for a maximum marks of 100.

Learning Outcomes-Based Curriculum Framework Guidelines Based Regulations For Post Graduate Programme	
Programme:	M.Sc., Physics
Programme Code:	07033
Duration:	2 Years (PG)
Programme outcomes (PO)	
PO1	**Disciplinary Knowledge** Capable of demonstrating detailed knowledge and expertise in all the Disciplines of the subject.
PO2	**Communication Skills** Able to express thoughts, ideas, concepts, scientific information, experiments and its significance effectively in writing and verbal, communicate with confidence to different groups, using appropriate media.
PO3	**Moral and Ethical Awareness** Ability to employ values in conducting one's life, use ethical practice at work, avoiding fabrication, misinterpretation and plagiarism, adhering to intellectual property rights and appreciate ethical solutions for environmental sustain ability.
PO4	**Analytical Reasoning** Ability to evaluate the reliability and relevance of evidence, identify flaws, analyze and synthesize data from different sources.
PO5	**Contribution to Society** Solve public issues concerned with public health and safety for the welfare of the society.
PO6	**Scientific Reasoning** Ability to identify, analyze, interpret and draw conclusions from qualitative and quantitative data, critically evaluate ideas, evidences and experiences, with an open mind and reasoned perspective.
PO7	**Employability Skill** Equip with skills, based on current trends and future expectations for career development and placements.
PO8	**Entrepreneurial Skill** To create efficient entrepreneurs by accelerating critical thinking, problem solving, decision making and leadership qualities to facilitate startups.

Programme Specific Outcomes (PSO)

On successful completion of the M.Sc. (Physics) programme, the students are expected to	
PSO1	**Placement:** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, and beliefs and apply diverse frames of reference to decisions and actions.
PSO2	**Entrepreneur:** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.
PSO3	**Research and Development:** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.
PSO4	**Contribution to Business World:** To produce employable, ethical and innovative professionals to sustain in the dynamic business world.
PSO5	**Contribution to the Society:** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

Methods of Evaluation		Marks	
Internal Evaluation	Continuous Internal Assessment Test	15	25
	Assignments with PPT	5	
	Class Participation /Group Discussion	5	
External Evaluation	End Semester Examination		75
Total			100

Methods 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 off beat situations, Discussion, Debating or Presentations

Total credits Post–Graduate Courses

Semester	Hours	Credits
I	30	20
II	30	22
III	30	26
	30	25
Total	**120**	**91**

Written Examination: Theory Paper (Bloom's Taxonomy based) Question paper Model

Assessment Pattern

Continuous Internal Assessment (CIA) & End Semester Examination (ESE)

- CIA : 25
- ESE: 75

Theory Course:

For theory courses there shall be two tests conducted by the faculty concerned and the average of the two can be taken as the Continuous Internal Assessment (CIA).CIA is for 30 marks max and will be converted in to 15 marks. The duration of each test shall be 1 ¼ Hrs.

Continuous Internal Assessment (Writing)	15marks
Assignment (PPT) & Seminar	5marks
Viva & Group Discussion	5marks

For theory Papers:

- Part A (10×1=10) Marks-Answer all questions (Multiple choice)
- Part B (5×5=25) Marks-Choosing either(a) or (b)
- Part C (5×8=40) Marks-Choosing either (a) or (b)

Total =75marks

Pedagogy:

- Technology Based Learning (PPT)
- Peer Teaching (Chalk & Talk)
- Virtual Lab
- Blended Learning (Online & Offline)
- Group Learning
- Self - Study
- Games Based Learning

Course Structure for Science Stream
First Year – Semester – I
M.Sc., Physics
(With effect from the academic year 2024 – 2025 onwards)

Semester I	Course Code	Title of the Course	Hrs/ Week L/P	Credits	Marks Allotted		
					CIA	ESE	Total
Core I	24PMPH11	Mathematical Physics	7	5	25	75	100
Core II	24PMPH12	Classical Mechanics and Relativity	6	5	25	75	100
Core III	24PMPHL1	General Physics and Electronics Experiments – I	6	4	40	60	100
Discipline Centric Elective – I (Choose any one from)	24PEPH11 24PEPH12 24PEPH13	1. Energy Physics 2. Astrosphysics 3. Plasma Physics	5	3	25	75	100
Discipline Centric Elective – II (Choose any one from)	24PEPH14 24PEPH15 24PEPH16	1. Linear and Digital ICs and Applications 2. Digital Communication 3. Communication Electronics	6	3	25	75	100
Total			**30**	**20**			

**** SEC-Skill Enhancement Course**

****EC –Elective Course**

Course Structure for Science Stream
First Year – Semester – II
M.Sc., Physics
(With effect from the academic year 2024 – 2025 onwards)

Semester II	Course Code	Title of the Course	Hrs/ Week L/P	Credits	Marks Allotted		
					CIA	ESE	Total
Core-IV	24PMPH21	Statistical Mechanics	6	5	25	75	100
Core-V	24PMPH22	Quantum Mechanics –I	6	5	25	75	100
Core-VI Practical-II	24PMPHL2	General Physics and Electronics Experiments – II	6	4	40	60	100
Elective- III (Discipline Centric)	24PEPH21 24PEPH22 24PEPH23	**Choose any one from** a) Advanced Optics b) Non Linear Dynamics c) Physics of Nano Science and Technology	4	3	25	75	100
Elective – IV (Industry Entrepreneurship)	24PEPH24 24PEPH25 24PEPH26	**Choose any one from** a) Microprocessor 8085 & Microcontroller 8051 b) Material Science c) Characterization of Materials	4	3	25	75	100
SEC – I (PCS)	24PSPH21	Physics for Competitive Examinations	**4**	**2**	**25**	**75**	**100**
Total			**30**	**22**			

**** SEC-Skill Enhancement Course** **** ESE- End Semester Examination**

****EC –Elective Course** ****CIA- Continuous Internal Assessment**

Course Structure for Science Stream
Second Year – Semester – III
M.Sc., Physics
(With effect from the academic year 2024 – 2025 onwards)

Semester III	Course Code	Title of the Course	Hrs/ Week L/P	Credits	Marks Allotted		
					CIA	ESE	Total
Core -VII	24PMPH31	Quantum Mechanics-II	5	5	25	75	100
Core - VIII	24PMPH32	Condensed Matter Physics	5	5	25	75	100
Core -IX	24PMPH33	Numerical Methods and Programming in C++	5	5	25	75	100
Core- X	24PMPHL3	Advanced Physics Experiments-I and Microprocessor 8085 & Microcontroller 8051 Programming	6	4	40	60	100
EC- V (Discipline Centric)	24PEPH31 24PEPH32 24PEPH33	Choose any one from 1) Spectroscopy 2) Crystal Growth and Thin Films 3) General Relativity and Cosmology	5	3	25	75	100
SEC – II (PCS)	24PSPH31	Sewage and Waste Water Treatment and Reuse	4	2	25	75	100
Training	24PTPH31	Internship / Field Visit / Industrial Visit/ Research Knowledge Updating Activity	-	2	50	50	100
Total			**30**	**26**			

**** SEC-Skill Enhancement Course** **** ESE- End Semester Examination**

****EC –Elective Course** ****CIA- Continuous Internal Assessment**

Course Structure for Science Stream
Second Year – Semester – IV
PG Physics
(With effect from the academic year 2024 – 2025 onwards)

Semester IV	Course Code	Title of the Course	Hrs/ Week L/P	Credits	Duration of ESE (Hrs.)	Marks Allotted		
						CIA	ESE	Total
Core - XI	24PMPH41	Nuclear and Particle Physics	6	5	3	25	75	100
Core XII	24PMPHL4	Advanced Physics Experiments – II and Numerical Methods in C++	6	5	3	40	60	100
Core - XIII	24PMPHP1	Project with Viva Voce	8	8	3	50	50	100
EC – VI (Select any one)	24PEPH41 24PEPH42 24PEPH43	1. Electromagnetic Theory 2. Quantum Field Theory 3. Advanced Mathematical Physics	6	4	3	25	75	100
SEC - III (Industry Oriented)	24PSPH41	Solar Energy Utilization	4	2	3	25	75	100
Extension Activity	24PEA41	Outreach Programme	-	1	1.5	50	50	100
Total			**30**	**25**				

**** SEC-Skill Enhancement Course** **** CIA- Continuous Internal Assessment**

**** EC –Elective Course** **** ESE- End Semester Examination**

Extension Activity :

1. **Report Submission - 50 Marks**
2. **Viva Voce - 50 Marks**

100 Marks

Semester - I
Mathematical Physics

Title of the Course		**Mathematical Physics**					
Course Type		**CORE - I**					
Year	**I**	**Semester**	**I**	**Credits**	**5**	**Course Code**	**24PMPH11**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**2**	--		**7**	

Learning Objectives	
LO1	To understand the Linear vector space
LO2	To understand complex analysis, probability & statistics
LO3	To learn the Eigen value of matrix, rank of matrix, Inverse matrix
LO4	To solve the Fourier Transforms and Laplace Transforms
LO5	To Understand the Hermite polynomials and Legendre polynomials in differential equations
UNIT	**CONTENTS**
I	**LINEAR VECTOR SPACE:** Basic concepts – Definitions- examples of vector space – Linear independence Scalar product- Orthogonality – Gram-Schmidt orthogonalization procedure – linear operators – Dual space- Ket and Bra notation – orthogonal basis – change of basis – Isomorphism of vector space– projection operator – orthogonal transformations and rotation for R^2 Vector space with standard basis.
II	**MATRICES:** Types of Matrices and their properties, Rank of a Matrix -Conjugate of a matrix - Adjoint of a matrix - Inverse of a matrix - Hermitian and Unitary Matrices Trace of a matrix- Transformation of matrices - Characteristic equation - Eigen values and Eigen vectors - Cayley–Hamilton theorem – Diagonalization
III	**COMPLEX NUMBERS, PROBABILITY & STATISTICS:** Review of Complex Numbers -de Moivre's Theorem-Functions of a Complex Variable- Differentiability -Analytic functions- Harmonic Functions- Complex Integration- Contour Integration, Cauchy – Riemann conditions – Singular points – Cauchy's Integral Theorem and integral Formula -Taylor's Series Laurent's Expansion- Zeros and poles – Residue theorem. Concept of groups- Abelian group-cyclic group- subgroups- classes- conjugate subgroups- Isomorphism and homomorphism – reducible and irreducible representations- character tables- construction of character tables for C_{2V} and C_{3V} point groups.

IV	**FOURIER TRANSFORMS & LAPLACE TRANSFORMS:** Definitions -Fourier series and transform and its inverse – Properties of FT - Fourier transform of derivatives - Cosine and sine transforms – Properties of FT –Applications of FT: Discrete Fourier Transform – Dimensional Fourier Transform. Laplace transform and its inverse - Transforms of derivatives and integrals – Differentiation and integration of transforms – Properties of LT – applications – Special Functions: Bessel function; Bessel function of the first kind – generating function
V	**DIFFERENTIAL EQUATIONS & TENSORS:** Second order differential equation- Sturm-Liouville's theory - Series solution with simple examples - Hermite polynomials - Generating function Orthogonality properties - Recurrence relations – Legendre polynomials Generating function - Rodrigue formula – Orthogonality properties - Dirac delta function - One dimensional Green's function and Reciprocity theorem. Tensors Field: Vector-fields, transformation of tensors - gradient and Laplace operator in general coordinates

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	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
CO 2	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.
CO 3	Analyze characteristics of matrices and its different types, and the process of diagonalization.
CO 4	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
CO 5	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.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved(To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. George Arfken and Hans J Weber, 2012, Mathematical Methods for Physicists – A Comprehensive Guide (7th edition), Academic press.
2. P.K. Chattopadhyay, 2013, *Mathematical Physics* (2^{nd} edition), New Age, New Delhi
3. A W Joshi, 2017, Matrices and Tensors in Physics, 4th Edition (Paperback), New Age International Pvt. Ltd., India
4. B. D. Gupta, 2009, *Mathematical Physics* (4^{th} edition), Vikas Publishing House, New Delhi.
5. H. K. Dass and Dr. Rama Verma, 2014, Mathematical Physics, Seventh Revised Edition, S. Chand & Company Pvt. Ltd., New Delhi.

Reference 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 East West, New Delhi.
5. C. R. Wylie and L. C. Barrett, 1995, Advanced Engineering Mathematics, 6 th Edition, International Edition, McGraw-Hill, New York

Web Sources:

1. https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=2411&print able=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/

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	3	3	3	3	2
CO 2	2	3	3	3	3	3	3	2
CO 3	3	3	3	2	2	3	3	2
CO 4	3	3	3	3	2	3	3	2
CO 5	3	2	3	3	2	3	3	2
Weightage	14	14	15	14	12	15	15	10
Weighted percentage of course contribution to POS	2.8	2.8	3	2.8	2.4	3	3	2

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	2	3	3	3	3
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	2	3	3	2
Weightage	14	14	15	14	10
Weighted percentage of Course Contribution to PSOs	2.8	2.8	3	2.8	2

Strong-3 M-Medium-2 L-Low-1

Classical Mechanics and Relativity

Title of the Course		Classical Mechanics And Relativity					
Course Type		CORE - II					
Year	I	Semester	I	Credits	5	Course Code	24PMPH12
Instructional Hours Per week		Lecture	Tutorial	Lab Practice		Total	
		5	1	--		6	

Learning Objectives

LO1	To understand the Linear vector space
LO2	To understand complex analysis, probability & statistics
LO3	To learn the Eigen value of matrix, rank of matrix, Inverse matrix
LO4	To solve the Fourier Transforms and Laplace Transforms
LO5	To Understand the Hermite polynomials and Legendre polynomials in differential equations

UNIT	CONTENTS
I	**PRINCIPLES OF CLASSICAL MECHANICS:** Mechanics of a single particle – conservation laws for a particle – mechanics of a system of particles – conservation laws for a system of particles – constraints – holonomic & non-holonomic constraints – generalized coordinates – configuration space – transformation equations – principle of virtual work.
II	**LAGRANGIAN FORMULATION:** D'Alembert's principle – Lagrangian equations of motion for conservative systems – applications: (i) simple pendulum (ii) Atwood's machine – Lagrange's equations in presence of non- conservative forces – Lagrangian for a charged particle moving in an electromagnetic field.
III	**HAMILTONIAN FORMULATION:** Phase space – generalized momentum and cyclic coordinates – Hamiltonian function and conservation of energy – Hamilton's canonical equations of motion – applications: (i) one dimensional simple harmonic oscillator (ii) motion of particle in a central force field.
IV	**SMALL OSCILLATIONS:** Stable and unstable equilibrium –Formulation of the problem: Lagrange's equations of motion for small oscillations – Properties of T, V and w –Normal co-ordinates and normal frequencies of vibration – free vibrations of a linear triatomic molecule.
V	**RELATIVITY:** Inertial and non-inertial frames – Lorentz transformation equations –Length contraction and Time dilation – relativistic addition of velocities – Einstein's mass-energy relation –Minkowski's space – four vectors – position, velocity, momentum, acceleration and force in four vector notation and their transformations.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Understand the fundamentals of classical mechanics.
CO 2	Apply the principles of Lagrangian mechanics to solve the equations of motion of physical systems.
CO 3	Apply the principles of Hamiltonian mechanics to solve the equations of motion of physical systems.
CO 4	Analyze the small oscillations in systems and determine their normal modes of oscillations.
CO 5	Understand and apply the principles of relativistic kinematics to the mechanical systems.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. H. Goldstein, *Classical Mechanics*, 3rd Edition, Pearson Edu.2002.
2. J. C. Upadhyaya, *Classical Mechanics*, Himalaya Publshing Co. New Delhi.
3. S.L. Gupta,V.Kumar, H.V. Sharma, Classical Mechanics, PrakatiPrakashan, Meerut.
4. R. Resnick, *Introduction to Special Theory of Relativity,* Wiley Eastern, New Delhi, 1968.
5. N. C. Rana and P.S. Joag, Classical Mechanics – Tata McGraw Hill, 2001

Reference books:

1. R. G. Takwala and P.S. Puranik, Introduction to Classical Mechanics –Tata – McGraw
2. Hill, New Delhi, 1980.
3. K. R. Symon, 1971, *Mechanics,* Addison Wesley, London.
4. S. N. Biswas, 1999, Classical *Mechanics*, Books & Allied, Kolkata.
5. T.W.B. Kibble, *Classical Mechanics*, ELBS.
6. Greenwood, *Classical Dynamics*, PHI, New Delhi.

Web Sources:
1. 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

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	3	3	2	2	2	3
CO 2	2	3	3	3	2	2	2	3
CO 3	2	3	3	3	2	2	2	3
CO 4	2	3	3	3	2	2	2	3
CO 5	2	3	3	3	2	2	2	3
Weightage	10	15	15	15	10	10	10	15
Weighted percentage of course contribution to POS	2	3	3	3	2	2	2	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	2	3	3	3	3
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	2	3	3	2
Weightage	14	14	15	14	10
Weighted percentage of Course Contribution to PSOs	2.8	2.8	3	2.8	2

Strong-3 M-Medium-2 L-Low-1

General Physics and Electronics Experiments – I

Title of the Course	**General Physics And Electronics Experiments – I**						
Course Type	**CORE – III – Lab - 1**						
Year	**I**	**Semester**	**I**	**Credits**	**4**	**Course Code**	**24PMPHL1**
Instructional Hours Per week	**Lecture**	**Tutorial**			**Lab Practice**		**Total**
	--	--			**6**		**6**

Learning Objectives	
LO1	To understand the concept of mechanical behavior of materials and calculation of same usingappropriate equations.
LO2	Application of Diffraction and Interference
LO3	Determination of some physical constants
LO4	To calculate the thermodynamic quantities and physical properties of materials.
LO5	To analyze the optical and electrical properties of materials.

Experiments

(Choose any SIX experiments from Part A and SIX from Part B)

PART A- General Physics Experiments

1. Determination of Young's modulus and Poisson's ratio by Hyperbolic fringes
2. Determination of Thickness of the enamel coating on a wire by diffraction
3. Measurement of Band gap energy of given semiconductor using Four-Probe method.
4. Determination of Planck Constant – LED Method
5. Determination of Compressibility of a liquid using Ultrasonic Interferometer
6. Determination of Wavelength, Separation of wavelengths using Michelson Interferometer
7. Accurate measurement of wavelength of Diode Laser using Diffraction grating.
8. Determination of Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
9. Measurement of Susceptibility of liquid
10. Determination of Self Inductance of the given coil using Anderson's Bridge method.
11. Determination of Crystallographic Parameters for the given XRD spectrum
    a) Unit cell determination b) W-H plot and interpretation
12. Measurement of RC Time constant (through discharging) and its theoretical verification

PART B – Electronics Experiments

1. Study of J,K,D and T flip-flop using IC7473
2. Verification of R-S flip-flop, clocked R-S flip-flop and D flip-flop using NAND gate
3. Important electrical characteristics of IC 741 (i/p and o/p impedance, Voltage Gain, CMRR).
4. Construction of a Constant current source using Transistor/FET and 741 and I-R characteristics(Floating and Grounded Load)
5. V- I and optical Characteristics of LEDs of different wavelengths.
6. Study of attenuation characteristics of Wien's bridge network and design of Wien's bridgeoscillator using Op-Amp.
7. Study of attenuation characteristics of Phase shift network and design of Phase shift oscillatorusing Op-Amp.
8. Construction of Schmitt trigger using IC741
9. Construction of square wave and Triangular wave generator using IC 741
10. Construction of pulse generator using the IC 741 – application as frequency divider
11. Construction of Op-Amp- 4-bit Digital to Analog converter (Binary Weighted and R/2R laddertype
12. Code Conversion: Binary to Gray and Gray to Binary

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Understand the strength of material using Young's modulus.
CO 2	Acquire knowledge of thermal behavior of the materials.
CO 3	Understand theoretical principles of magnetism through the experiments.
CO 4	Acquire knowledge about arc spectrum and applications of laser
CO 5	Improve the analytical and observation ability in Physics Experiments

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Practical Physics, Gupta and Kumar, PragatiPrakasan.
2. Kit Developed for doing experiments in Physics- Instructionmanual, R.Srinivasan K.R Priolkar,
3. Indian Academy of Sciences.
4. Electronic Laboratory Primer a design approach , S. Poornachandra, B.Sasikala,
5. Wheeler Publishing, New Delhi.
6. Electronic lab manual Vol I, K ANavas, Rajath Publishing.
7. Electronic lab manual Vol II, K ANavas, PHI eastern EconomyEdition

Reference books:

1. Advanced Practical Physics, S.P Singh, PragatiPrakasan.
2. An advanced course in Practical Physics, D.Chattopadhayay, C.RRakshit, 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

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	2	3	2	2	2	1
CO 2	2	2	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3
CO 4	3	2	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	2	2
Weightage	13	12	14	15	14	14	13	12
Weighted percentage of course contribution to POS	2.6	2.4	2.8	3	2.8	2.8	2.6	2.4

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	2	3	3	3
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3
Weightage	13	12	14	15	14
Weighted percentage of Course Contribution to PSOs	2.6	2.4	2.8	3	2.8

Energy Physics

Title of the Course	**Energy Physics**						
Course Type	**ELECTIVE - I**						
Year	**I**	**Semester**	**I**	**Credits**	**3**	**Course Code**	**24PEPH11**
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**			**Total**
		3	**2**	**--**			**5**
Pre-requisite	Knowledge of conventional energy resources						
Learning Objectives							
LO1	To learn about various renewable energy sources.						
LO2	To know the ways of effectively utilizing the oceanic energy.						
LO3	To study the method of harnessing wind energy and its advantages.						
LO4	To learn the techniques useful for the conversion of biomass into useful energy.						
LO5	To know about utilization of solar energy						
UNIT	**CONTENTS**						
I	**INTRODUCTION TO ENERGY SOURCES:** A brief survey of conventional and non-conventional energy sources and their availability–present and future needs-. prospects of Renewable energy sources– Energy from other sources– chemical energy–Nuclear energy– Energy storage and distribution.						
II	**ENERGY FROM THE OCEANS:** Energy utilization–Energy from tides–Basic principle of tidal power–utilization of tidal energy – Principle of ocean thermal energy conversion systems.						
III	**WIND ENERGYSOURCES:** Basic principles of wind energy conversion–power in the wind–forces in the Blades– Wind energy conversion–Advantages and disadvantages of wind energy conversion systems (WECS) - Energy storage–Applications of wind energy.						
IV	**ENERGY FROM BIOMASS:** Biomass conversion Technologies– wet and dry process–Photosynthesis Biogas Generation: Introduction–basic process: Aerobic and anaerobic digestion – Advantages of anaerobic digestion–factors affecting bio digestion and generation of gas- bio gas from waste fuel– properties of biogas-utilization of biogas.						
V	**SOLAR ENERGY SOURCES:** Solar radiation and its measurements–solar cells: Solar cells for directconversion of solar energy to electric powers–solar cell parameter–solar cell electrical characteristics– Efficiency–solar distillation––solar greenhouse – Solar pond and its applications.						

Course Outcomes:

Course Outcomes: CO	On completion of this 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.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. G.D. Rai, 1996, Non – convention sources of, 4th edition, Khannapublishers,
2. NewDelhi.
3. S. Rao and Dr. ParuLekar, Energy technology.
4. M.P. Agarwal, Solar Energy, S. Chand and Co., New Delhi (1983).
5. Solar energy, principles of thermal collection and storage by S.P.Sukhatme, 2nd edition,
6. Tata McGraw-Hill Publishing Co. Lt., NewDelhi (1997).
7. 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&print able=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/

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	3	3	2	2	2	3
CO 2	2	3	3	3	2	2	2	3
CO 3	2	3	3	3	2	2	2	3
CO 4	2	3	3	3	2	2	2	3
CO 5	2	3	3	3	2	2	2	3
Weightage	10	15	15	15	10	10	10	15
Weighted percentage of course contribution to POS	2	3	3	3	2	2	2	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	2
CO2	2	3	3	3	2
CO3	2	3	3	3	2
CO4	2	3	3	3	2
CO5	2	3	3	3	2
Weightage	10	15	15	15	10
Weighted percentage of Course Contribution to PSOs	2	3	3	3	2

Strong-3 M-Medium-2 L-Low

Astrophysics

Title of the Course	**Astrophysics**						
Course Type	**ELECTIVE - I**						
Year	**I**	**Semester**	**I**	**Credits**	**3**	**Course Code**	**24PEPH12**
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		3	**2**	**--**		**5**	

Learning Objectives	
LO1	To impart knowledge on the physical universe and its evolution
LO2	To make the student to understand fundamental principles and techniques of astronomy and astrophysics
LO3	To make the student to study electromagnetic radiation from stars, atomic spectra and Classification of stars
LO4	To provide information about the properties and the evolution of stars
LO5	To render information about astronomical instrumentation

UNIT	**CONTENTS**
I	**OBSERVATIONAL ASTRONOMY:** The electromagnetic spectrum; geometrical optics (ray diagrams, focal length, magnification etc); diffraction (resolving power, Airy disc, diffraction limit etc); telescopes (reflecting, refracting, multi wavelength)
II	**PROPERTIES OFSTARS:** Brightness (luminosities, fluxes and magnitudes); colours (black body radiation, the Planck, Stefan-Boltzmann and Wien's laws, effective temperature, interstellar reddening); spectral types; spectral lines (Bohr model, Lyman & Balmer series etc, Doppler effect); Hertzprung Russelldiagram; the main sequence (stellar masses ,binary systems, Kepler's laws, mass-luminosity relations); distances to stars (parallax, standard candles, P-L relationships, ms-fitting etc); positions of stars (celestial sphere, coordinate systems, proper motions, sidereal and universal time).
III	**THE LIFE AND DEATH OF STARS:** Energy source (nuclear fusion, p-pchain, triple-alpha, CNO cycle, lifetime of the Sun); solar neutrinos; basic stellar structure hydro static equilibrium, equation of state);evolution beyond the main sequence; formation of the heavy elements; supernovae; stellar remnants(white dwarfs, neutron stars, black holes, degeneracy pressure, Swarszchild radius, escape velocities).

IV	**GALAXIES:** Constituents of galaxies; stellar populations; the interstellar medium; HII regions; 21cm line; spirals and ellipticals; galactic dynamics; galaxy rotation curves and dark matter ; active galaxies and quasars.
V	**COSMOLOGY:** Galaxies and the expanding Universe; Hubble's Law; the age of the Universe; the Big Bang; cosmic microwave background (black body radiation);big bang nucleosynthesis (cosmic abundances, binding energies, matter & radiation); introductory cosmology (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.

Course Outcomes:

Course Outcomes: CO	On completion of this 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 variouslaws 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 thepresence of dark matter in theuniverse. Explain, howquasars and active galaxies are powered by supermassiveblack holes which produce copious luminosity.
CO5	Explain cosmology, a branch of astronomy that involvesthe origin and evolution ofthe universe, from the Big Bangto today and on into the future. Define Hubble's law ofcosmic expansion. Analyze and assess the big bangnucleosynthesis universe that explains the relative.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Zeilik & Gregory, Introductory Astronomy & Astrophysics,4thedition(Saunders College
2. Publishing)
3. Morison,I., Introduction to Astronomy and Cosmology, (Wiley)
4. Kutner, M.L., Astronomy: A Physical Perspective (Cambridge University Press)
5. Green, S.F. & Jones, M.H., An Introduction to the Sun and Stars (Cambridge University Press)

Reference books:

1. Jones,M.H. & Lambourne, R.J.A., An Introduction to Galaxies & Cosmology (Cambridge University Press)
2. Carroll,B.W.& Ostlie, D.A.,An Introduction to Modern Astrophysics (Pearson)
3. Shu,F.H.,The Physical Universe, An Introduction to Astronomy,(University Science Books)
4. Motz,L.&Duveen,A.,The Essentials of Astronomy,(Colombia University Press

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
5. https://merriam-webster.com

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	1	2	1	3	2
CO 2	3	2	3	1	2	1	3	2
CO 3	3	2	3	1	2	1	3	2
CO 4	3	2	3	1	2	1	3	2
CO 5	3	2	3	1	2	1	3	2
Weightage	15	10	15	5	10	5	15	10
Weighted percentage of course contribution to POS	3	2	3	1	2	1	3	2

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	1	2
CO2	3	2	3	1	2
CO3	3	2	3	1	2
CO4	3	2	3	1	2
CO5	3	2	3	1	2
Weightage	15	10	15	5	10
Weighted percentage of Course Contribution to PSOs	3	2	3	1	2

Strong-3 M-Medium-2 L-Low-1

Plasma Physics

Title of the Course	**Plasma Physics**						
Course Type	**ELECTIVE - I**						
Year	**I**	**Semester**	**I**	**Credits**	**3**	**Course Code**	**24PEPH13**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	3	**2**	**--**	**5**

Pre-requisite	Fundamentals of Electricity and Magnetism, Electromagnetic theory, Maxwell's equation, Basic knowledge of electrical and electronics instrumentation.

Learning Objectives

LO1	To explore the plasma universe by means of in-site and ground-based observations.
LO2	To understand the model plasma phenomena in the universe.
LO3	To explore the physical processes which occur in the space environment.
LO4	To provide plasma diagnostics techniques
LO5	To explore the applicationsof plasma physics

UNIT	**CONTENTS**
I	**FUNDAMENTALCONCEPTS OF PLASMA:** Kinetic pressure in a partially ionized - mean free path and collision cross section - Mobility of charged particles - Effect of magnetic field on the mobility of ions and electrons-Thermal conductivity- Effect of magnetic field- Quasi-neutrality of plasma Debye shielding distance – Optical properties of plasma.
II	**MOTION OF CHARGED PARTICLES IN ELECTRIC AND MAGNETIC FIELD:** Particle description of plasma- Motion of charged particle in electrostatic field- Motion of charged particle in uniform magnetic field - Motion of charged particle in electric and magnetic fields-Motion of charged particleinhomogeneous magnetic field - Motion of charged particle in magnetic mirror confinement - motion of an electron in a time varying electric field-Magneto-hydrodynamics - Magneto-hydrodynamic equations – Condition for magneto hydrodynamic behaviour.
III	**PLASMA OSCILLATIONSAND WAVES:** Introduction, theory of simple oscillations - electron oscillation in a plasma – Derivations of plasma oscillations by using Maxwell's equation - Ion oscillation and waves in a magnetic field - thermal effects on plasma oscillations - Landau damping - Hydro magnetic waves - Oscillations in an electron beam.

IV	**PLASMA DIAGNOSTICS TECHNIQUES:** Single probe method - Double probe method - Use of probe technique formeasurement of plasma parameters in magnetic field - microwave method - spectroscopic method - -laser as a tool for plasma diagnostics-X-ray diagnostics of plasma - acoustic method - conclusion.
V	**APPLICATIONSOF PLASMA PHYSICS:** Magneto hydrodynamic Generator - Basic theory - Principle of Working Fuel in MHD Generator - Generation of Microwaves Utilizing High Density Plasma - Plasma Diode.

Course Outcomes:

Course Outcomes: CO	On completion of this 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.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Plasma Physics- Plasma State of Matter - S. N.Sen, PragatiPrakashan, Meerut.
2. Introduction to Plasma Physics-M. Uman
3. Krall, N. A., and A. W. Trivelpiece. Principles of Plasma Physics. Berkeley, CA: San Francisco Press, 1986. ISBN: 9780911302585.
4. Tanenbaum, B. S. Plasma Physics. New York, NY: McGraw-Hill, 1967. ISBN: 9780070628120.
5. Goldston, R. J., and P. H. Rutherford. Introduction to Plasma Physics. Philadelphia, PA: IOP Publishing, 1995. ISBN: 9780750301831.
6. Hutchinson, I. H. Principles of Plasma Diagnostics. Cambridge, UK:Cambridge University Press, 2005. ISBN: 9780521675741.

Reference books:
1. Chen, F. F. Introduction to Plasma Physics. 2nd ed. New York, NY:Springer, 1984. ISBN: 9780306413322. 2. Introduction to Plasma Theory-D.R. Nicholson 3. Shohet, J. L. The Plasma State. San Diego, CA: Academic Press Inc.,1971. ISBN: 9780126405507. 4. Hazeltine, R. D., and F. L. Waelbroeck. The Framework of PlasmaPhysics. Boulder, CO: Westview Press, 2004. ISBN: 9780813342139. 5. Huddlestone, R. H., and S. L. Leonard. Plasma DiagnosticTechniques. San Diego, CA: Academic Press, 1965
Web resources:
1.https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=2411&print able=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/

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	1	1	2	1	2
CO 2	3	3	2	1	1	2	1	2
CO 3	3	3	2	2	1	2	1	3
CO 4	3	3	3	2	1	2	1	3
CO 5	3	3	3	2	1	2	1	3
Weightage	15	15	12	8	5	10	5	13
Weighted percentage of course contribution to POS	3	3	2.4	1.6	1	2	1	2.6

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	1
CO2	3	3	2	1	1
CO3	3	3	2	2	1
CO4	3	3	3	2	1
CO5	3	3	3	2	1
Weightage	15	15	13	8	5
Weighted percentage of Course Contribution to PSOs	3	3	2.6	1.6	1

Linear and Digital Ics & Applications (Discipline Centric)

<table>
<tr><td>Title of the Course</td><td colspan="7">Linear And Digital Ics & Applications</td></tr>
<tr><td>Course Type</td><td colspan="7">ELECTIVE - II</td></tr>
<tr><td>Year</td><td>I</td><td>Semester</td><td>I</td><td>Credits</td><td>3</td><td>Course Code</td><td>24PEPH14</td></tr>
<tr><td rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">4</td><td colspan="2">2</td><td colspan="2">--</td><td>6</td></tr>
<tr><td>Pre-requisite</td><td colspan="7">Knowledge of semiconductor devices, basic concepts of digital and analog electronics</td></tr>
<tr><td colspan="8">Learning Objectives</td></tr>
<tr><td>LO1</td><td colspan="7">To introduce the basic building blocks of linear integrated circuits.</td></tr>
<tr><td>LO2</td><td colspan="7">To teach the linear and non-linear applications of operational amplifiers.</td></tr>
<tr><td>LO3</td><td colspan="7">To introduce the theory and applications of PLL.</td></tr>
<tr><td>LO4</td><td colspan="7">To introduce the concepts of waveform generation and introduce one special functionICs.</td></tr>
<tr><td>LO5</td><td colspan="7">Exposure to digital IC‘s</td></tr>
<tr><td>UNIT</td><td colspan="7">CONTENTS</td></tr>
<tr><td>I</td><td colspan="7">INTEGRATED CIRCUITS ANDOPERATIONALAMPLIFIER: Introduction, Classification of IC‘s, Op-Amp 741 and its features, the idealOperational amplifier, Op-Amp internal circuit diagram, Op-Amp Characteristics – Inverting and Non-Inverting Modes of operation- DC and AC performance Characteristics.</td></tr>
<tr><td>II</td><td colspan="7">APPLICATIONS OF OP-AMP: Linear applications of Op-Amp: Solution to simultaneous equations and differential equations, Instrumentation amplifiers, V to I and I to V converters.
Non-linear applications of Op-Amp: Sample and Hold circuit, Log and Antilog amplifier, multiplier and divider, Comparators, Schmitt trigger, Multivibrators, Triangular and Square waveform generators.</td></tr>
</table>

III	**ACTIVE FILTERS &TIMER AND PHASE LOCKED LOOPS: Active filters:** Introduction, Butterworth filters – 1st order, 2nd order lowand high pass filters, band pass, band reject and All pass filters- Applications.**Timer and Phase Locked Loops:** Introduction to IC 555 timer, description of functional diagram, monostable and astable operations and applications, Schmitt trigger, voltage controlled oscillator (IC 566), PLL - introduction, basic principle, phase detector/comparator, monolithic PLL (IC565) and applications.
IV	**VOLTAGE REGULATOR & D to A AND A to D CONVERTERS: Voltage Regulators:** Introduction, Series Op-Amp regulator, IC Voltage Regulators, IC 723 general purpose regulators, Switching Regulator. **DAC and ADC:** Introduction, basic DAC techniques weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, A to D converters -parallel comparator type ADC, counter type ADC, dual slope ADC, DAC and ADC Specifications.
V	**CMOS LOGIC, COMBINATIONAL CIRCUITS USING TTL 74XX ICs** & **SEQUENTIAL CIRCUITS USINGTTL 74XX ICs: CMOS Logic**: CMOS logic levels, MOS transistors, Basic CMOS Inverter, NAND and NOR gates, CMOS AND-OR-INVERT and OR AND- INVERT gates, implementation of any function using CMOS logic. **Sequential circuits using TTL 74xx ICs:** Flip Flops (IC 7474, IC 7473), Shift Registers, Universal Shift Register (IC 74194), 4- bit asynchronous binary counter (IC 7493).

Course Outcomes:

Course outcomes:	On completion of this course, the students will be able to: CO
CO1	Learn about the basic concepts for the circuit configuration for the design oflinear integrated circuits and develops skill to solve problems
CO2	Develop skills to design linear and non-linear applications circuits usingOpAmp and design the active filters circuits.
CO3	Gain knowledge about PLL, and develop the skills to design the simple circuitsusing 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 sequentialcircuits

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. D. Roy Choudhury, Shail B. Jain (2012), Linear Integrated Circuit, 4thedition, New Age International Pvt.Ltd., NewDelhi,India.
2. Ramakant A. Gayakwad, (2012), OP-AMP and Linear IntegratedCircuits, 4th edition, Prentice Hall / Pearson Education, NewDelhi.
3. B.L. Theraja and A.K. Theraja, 2004, A Textbook of Electricaltechnology, S. Chand & Co.
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 analogintegrated circuits, McGraw Hill, New Delhi.
2. Gray, Meyer (1995), Analysis and Design of Analog Integrated Circuits,Wiley International, New Delhi.
3. Malvino and Leach (2005), Digital Principles and Applications 5thEdition, Tata McGraw Hill, New Delhi
4. Floyd, Jain (2009), Digital Fundamentals, 8th edition, PearsonEducation, New Delhi.

Integrated Electronics, Millman&Halkias, Tata McGraw Hill, 17thReprint (2000)

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/chpt7/field-effect-controlled-thyristors/
4. https://www.electrical4u.com/applications-of-op-amp/
5. https://www.geeksforgeeks.org/digital-electronics-logic-designtutorials/

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	3	2	2	3	3
CO 2	3	3	3	3	1	3	3	3
CO 3	3	3	3	3	1	3	3	3
CO 4	3	3	3	3	1	3	3	3
CO 5	3	3	3	2	1	1	2	3
Weightage	15	15	15	14	6	12	14	15
Weighted percentage of course contribution to POS	3	3	3	2.8	1.2	2.4	2.8	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	1
CO3	3	3	3	3	1
CO4	3	3	3	3	1
CO5	3	3	3	2	1
Weightage	15	15	15	14	6
Weighted percentage of Course Contribution to PSOs	3	3	3	2.8	1.2

Strong-3 M-Medium-2 L-Low-1

Digital Communication (Discipline Centric)

Title of the Course	**Digital Communication**						
Course Type	**ELECTIVE - II**						
Year	**I**	**Semester**	**I**	**Credits**	**3**	**Course Code**	**24PEPH15**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	4	**2**	**--**	**6**

Learning Objectives	
LO1	To understand the use of Fourier, transform in analyzing the signals
LO2	To learn about the quanta of transmission of information
LO3	To make students familiar with different types of pulse modulation
LO4	To have an in depth knowledge about the various methods of error controlling codes
LO5	To acquire knowledge about spread spectrum techniques in getting secured communication

UNIT	CONTENTS
I	**SIGNAL ANALYSIS:** Fourier transforms of gate functions, delta functions at the origin – Two deltafunction and periodic delta function – Properties of Fourier transform – Frequency shifting –Time shifting - Convolution –Graphical representation – Convolution theorem – Time Convolution theorem – Frequency Convolution theorem –Sampling theorem.
II	**INFORMATION THEORY:** Communication system – Measurement of information – Entropy- Source Encoding - Coding – Baudot Code CCITT Code – Hartley Law – Noise in an information Carrying Channel- Effects of noise- Capacity of noise in a channel – Channel capacity of continuous channel- Shannon Hartley theorem –Redundancy- Practical communication system in lights of Shannon theorem.
III	**PULSE MODULATION:** Pulse amplitude modulation - natural sampling – Instantaneous sampling - Transmission of PAM Signals -Pulse width modulation – Time division multiplexing – Band width requirements for PAM Signals. Pulse Code Modulation –Principles of PCM –Quantizing noise – Generation and demodulation of PCM -Effects of noise –Companding – Advantages and application.
IV	**ERROR CONTROLCODING:** Error Correcting Codes Introduction, Linear Block Code, Hamming Codes, Cyclic Code, Burst error detecting and correcting codes, Interlace codes for burst and random error correction, Convolution Code, Grain Viterbi decoding Comparison of coded and un coded system.**DAC and ADC:** Introduction, basic DAC techniques weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, A to D converters -parallel comparator type ADC, counter type ADC, successive approximation ADC and dual slope ADC, DAC and ADC Specifications.
V	**SPREAD SPECTRUM SYSTEMS**: Introduction to spread spectrum, spread spectrum techniques, Pseudo noise sequences - generation and Correlation properties- Direct sequence system,frequency hopping system, pulse FM (chirp) system, hybrid systems. Processing gain, anti-jam and multipath performance.

Course Outcomes:

Course outcomes:	On completion of this course, the students will be able to: CO
CO1	Apply the techniques of Fourier transform, convolution and sampling theorems in signal processing.
CO2	Apply different information theories in the process of study of coding of information, storage and communication
CO3	Explain and compare the various methods of pulse modulation techniques.
CO4	Apply the error control coding techniques in detecting and correcting errors-ableto discuss, analyze and compare the different error control coding.
CO5	Apply, discuss and compare the spread spectrum techniques for secure communications
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytica ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. B.P. Lathi, *Communication system*, Wiley Eastern.
2. George Kennedy, *Electronic CommunicationSystems,* 3rd Edition, Mc Graw Hill.
3. Simon Haykin, *Communication System*, 3rd Edition, John Wiley &Sons.
4. George Kennedy and Davis, 1988, *Electronic CommunicationSystem,* Tata McGraw Hill 4th Edition.
5. Taube and Schilling, 1991, *"Principles of Communication System"*,Second edition Tata McGraw Hill
6. Modern Digital and Analog Communication Systems, B. P. Lathi,(3rd Edition), Oxford Publication
7. Principles of Communication Systems, Taub & Schilling, (2ndEdition), Tata McGraw Hill Publication
8. S.Haykin, Communication systems, John Wiley 2001 4. Bhattacharya Amitabh, "Digital Communication", Tata McGraw-Hill, 1stEd., 2006.
9. R. C. Dixen, "Spread Spectrum Systems with commercialapplication", John Wiley, 3rd Ed.

Reference Books:

1. John Proakis, 1995, *Digital Communication*, 3rd Edition, McGrawHill, Malaysia.
2. M. K. Simen, 1999, *Digital Communication Techniques, SignalDesign and Detection*, Prentice Hall of India.
3. Dennis Roddy and Coolen, 1995, *Electronics communications,*Prentice Hall of India IV Edition.
4. Wave Tomasi, 1998, *"Advanced Electronics communication System"* 4th Edition Prentice Hall, Inc.
5. M.Kulkarni, 1988, *"Microwave and Radar Engineering",* Umesh Publications.

Web resources:

1. http://nptel.iitm.ac.in/
2. http://web.ewu.edu/
3. http://www.ece.umd.edu/class/enee630.F2012.html
4. http://www.aticourses.com/Advanced%20Topics%20in%20Digital%20Signals
5. http://nptel.iitm.ac.in/courses/117101051.html

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	1	2	2	3	2
CO 2	3	3	3	1	2	2	3	2
CO 3	3	3	3	1	2	2	3	2
CO 4	3	3	3	1	2	2	3	2
CO 5	3	3	3	1	2	2	3	2
Weightage	15	15	15	5	10	10	15	10
Weighted percentage of course contribution to POS	3	3	3	1	2	2	3	2

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	2
CO2	3	3	3	1	2
CO3	3	3	3	1	2
CO4	3	3	3	1	2
CO5	3	3	3	1	2
Weightage	15	15	15	5	10
Weighted percentage of Course Contribution to PSOs	3	3	3	1	2

Communication Electronics (Discipline Centric))

Title of the Course	**Communication Electronics**						
Course Type	**ELECTIVE - II**						
Year	**I**	**Semester**	**I**	**Credits**	**3**	**Course Code**	**24PEPH16**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	4	**2**	**--**	**6**

Learning Objectives	
LO1	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
LO2	To gain knowledge in the generation and propagation of microwaves
LO3	To acquire knowledge about radar systems and its applications and also the working principle of colour television
LO4	To learn the working principle of fiber optics and its use in telecommunication
LO5	To understand the general theory and operation of satellite communication systems
UNIT	**CONTENTS**
I	**ANTENNAS AND WAVE PROPAGATION:** Radiation field and radiation resistance of short dipole antenna groundedantenna-ungrounded antenna-antenna arrays-broadside and end side arrays-antenna gain-directional high frequency antennas-sky wave- ionosphere- Eccles and Larmor theory-Magneto ionic theory- ground wave propagation.
II	**MICROWAVES:** Microwave generation—multi cavity Klystron-reflex klystron magnetrontravelling wave tubes (TWT) and other microwave tubes MASER-Gunndiode-wave guides-rectangular wave guides-standing wave indicator and standing wave ratio(SWR)

III	**RADAR ANDTELEVISION:** Elements of a radar system-radar equation-radar performance Factors radar transmitting systems-radar antennas-duplexers radar receivers andindicators-pulsed systems-other radar systems colour TV transmission and reception-colour mixing principle-colour picture tubes-Delta gun picture tube-PIL colour picture tube-cable TV, CCTV and theatre TV
IV	**SATELLITE COMMUNICATION: Voltage Regulators:** Orbital satellites-geostationary satellites-orbital patterns-satellite systemlink models-satellite system parameters-satellite system link equation link budget-INSAT communication satellites.
V	**EARTH STATION TECHNOLOGY:** Transmitters, Receivers, Antennas, Tracking systems, Terrestrial Interface, Power Test methods, Lower Orbit Considerations. Satellite Navigation & Global Positioning Systems: Radio and Satellite Navigation, GPS Position Location principles, GPS Receivers, GPS C/A code accuracy, Differential GPS.

Course Outcomes:

Course outcomes:	On completion of this course, the students will be able to: CO
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 ofradar 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 justifythe 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

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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, secondedition, Tata Mc Graw Hill (1991).
4. M. Kulkarani, Microwave and radar engineering,Umesh Publications, 1998.
5. Mono Chrome and colour television, R. R. Ghulathi
6. Satellite Communication Engineering- Wilbur L. Pritchand, RobertA Nelson and Henri G.Suyderhoud, 2nd Edition, Pearson Publications.
7. Digital Satellite Communications-Tri. T.Ha, 2nd Edition, 1990, Mc. Graw Hill.

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 Roddyand Coolen,1995, *Electronicscommunications,* 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, ElectronicDevices and Circuits, Tata McGraw-Hill Publishing Company Limited,New Delhi, Second Edition.

Web resources:

1. https://www.geeksforgeeks.org/digital-electronics-logic-designtutorials/
2. https://www.polytechnichub.com/difference-analog-instrumentsdigital-instruments/
3. http://nptel.iitm.ac.in/
4. http://web.ewu.edu/
5. http://nptel.iitm.ac.in/

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	1	2	2	3	2
CO 2	3	3	3	1	2	2	3	2
CO 3	3	3	3	1	2	2	3	2
CO 4	3	3	3	1	2	2	3	2
CO 5	3	3	3	1	2	2	3	2
Weightage	15	15	15	5	10	10	15	10
Weighted percentage of course contribution to POS	3	3	3	1	2	2	3	2

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	2
CO2	3	3	3	1	2
CO3	3	3	3	1	2
CO4	3	3	3	1	2
CO5	3	3	3	1	2
Weightage	15	15	15	5	10
Weighted percentage of Course Contribution to PSOs	3	3	3	1	2

Strong-3 M-Medium-2 L-Low-1

Semester - II
Statistical Mechanics

Title of the Course		**Statistical Mechanics**					
Course Type		**CORE - IV**					
Year	**I**	**Semester**	**II**	**Credits**	**5**	**Course Code**	**24PMPH21**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**1**	--		**6**	

Learning Objectives	
LO1	To acquire the knowledge of thermodynamic potentials and to understand phase transition in thermodynamics
LO2	To identify the relationship between statistics and thermodynamic quantities
LO3	To comprehend the concept of partition function, canonical and grand canonical ensembles
LO4	To grasp the fundamental knowledge about the three types of statistics
LO5	To get in depth knowledge about phase transitions and fluctuation of thermodynamic properties that vary with time
UNIT	**CONTENTS**
I	**STATISTICAL MECHANICS:** Introduction to statistical mechanics - Phase space – Ensembles and their types – Liouville's theorem – Postulate of equal priori probability – Microstates and Macrostates – Stirling's formula – The most probable distribution – Law of equipartition of energy - Entropy and probability – Probability distribution and entropy of a two level system – Negative temperature.
II	**MICRO CANONICAL AND GRAND CANONICAL ENSEMBLES:** Microcanonical ensemble (Isolated system) – Perfect gas in Microcanonical ensemble – Gibbs paradox – Partition function and its correlation with thermodynamic quantities - Grand canonical ensemble (system with an infinite number of particles) – Partition function and thermodynamic functions for Grand canonical ensemble – Perfect gas in Grand canonical ensemble – Applications: Mean kinetic energy of a molecule in a gas, Brownian motion and Harmonic oscillator.
III	**CLASSICAL AND QUANTUM STATISTICS:** Density matrix - Density matrix in micro canonical, canonical and grand canonical ensembles - Bose-Einstein statistics - Maxwell-Boltzmann statistics - Fermi-Dirac statistics – Black-body radiation and the Planck radiation law - Bose-Einstein gas - Gas Degeneracy- Bose-Einstein condensation – Fermi- Dirac gas- Weak degeneracy- Specific heat of solids: Dulong and Pettit's law - Einstein's Theory - Debye theory.

IV	**LOW TEMPERATURE**, **ISINGMODEL AND FLUCTUATIONS:** Production of Low Temperature – Measurement of Low temperature – Approach to absolute zero by adiabatic demagnetization : Principle, Method, Theory and T-S diagram – Conversion of magnetic temperature to Kelvin temperature - Fluctuations and transport phenomena – Brownian movement –Motion due to fluctuating force: The Fokker - Planck equation – Fluctuation in energy and pressure
V	**THERMODYNAMICS AND PHASE TRANSITIONS:** Thermodynamic potentials and the reciprocity relations - Thermodynamic Equilibrium - Gibb's phase rule - Third law of Thermodynamics - Phase transitions of first and second kind – Landau's theory of Phase transition- Phase Transitions of the second kind: The Ising model – Bragg-Williams approximation - One dimensional Ising model.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	To examine and elaborate the effect of changes in thermodynamic quantities on the states of matter during phase transition
CO 2	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 behavior of the entropy by mixing two gases Justify the connection between statistics and thermodynamic quantities
CO 3	Differentiate between canonical and grand canonical ensembles and to interpret the relation between thermodynamical quantities and partition function
CO 4	To recall and apply the different statistical concepts to analyze the behavior of ideal Fermi gas and ideal Bose gas and also to compare and distinguish between the three types of statistics.
CO 5	To discuss and examine the thermodynamical behavior of gases under fluctuation and also using Ising model
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved(To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Dr. S. L. Gupta and Dr. V. Kumar, 2008, Elementary Statistical Mechanics, 22nd Edition, Pragati Prakashan, Meerut.
2. S. K. Sinha, 1990, Statistical Mechanics, Tata McGraw Hill, New Delhi.
3. B. K. Agarwal and M. Eisner, 1998, Statistical Mechanics, Second Edition New Age International, New Delhi.
4. J. K. Bhattacharjee, 1996, Statistical Mechanics: An Introductory Text, Allied Publication, New Delhi.
5. F. Reif, 1965, Fundamentals of Statistical and Thermal Physics, McGraw -Hill, New York.
6. M. K. Zemansky, 1968, Heat and Thermodynamics, 5th edition, McGrawHill New York.

Reference books:

1. R. K. Pathria, 1996, Statistical Mechanics, 2nd edition, Butter Worth Heinemann, New Delhi.
2. L. D. Landau and E. M. Lifshitz, 1969, Statistical Physics, Pergamon Press, Oxford.
3. K. Huang, 2002, Statistical Mechanics, Taylor and Francis, London
4. W. Greiner, L. NeiseandH.Stoecker, Thermodynamics and Statistical Mechanics, Springer Verlang, New York.
5. A. B. Gupta, H. Roy, 2002, Thermal Physics, Books and Allied, Kolkata.

Web Sources:

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

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	1	1	2	3	1
CO 2	3	3	3	1	1	2	3	1
CO 3	3	3	3	1	1	2	3	2
CO 4	3	3	3	1	1	2	3	2
CO 5	3	3	3	1	1	2	3	1
Weightage	15	15	15	5	5	10	15	7
Weighted percentage of course contribution to POS	3	3	3	1	1	2	3	1.4

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	1
CO2	3	3	3	1	1
CO3	3	3	3	1	1
CO4	3	3	3	1	1
CO5	3	3	3	1	1
Weightage	14	15	15	5	5
Weighted percentage of Course Contribution to PSOs	3	3	3	1	1

Strong-3 M-Medium-2 L-Low-1

Quantum Mechanics – I

Title of the Course		**Quantum Mechanics – I**					
Course Type		**CORE - V**					
Year	**I**	**Semester**	**II**	**Credits**	**5**	**Course Code**	**24PMPH22**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**1**	**--**		**6**	

Learning Objectives

LO1	To develop the physical principles and the mathematical background important to quantum mechanical descriptions.
LO2	To describe the propagation of a particle in a simple, one-dimensional potential.
LO3	To formulate and solve the Schrodinger's equation to obtain eigenvectors and energies for particle in a three-dimensional potential
LO4	To explain the mathematical formalism and the significance of constants of motion, and see their relation to fundamental symmetries in nature
LO5	To discuss the Approximation methods like perturbation theory, Variational and WKB methods for solving the Schrödinger equation.
UNIT	**CONTENTS**
I	**BASIC FORMALISM:** Wave Mechanical Concepts: Wave packet - Time dependent Schrodinger equation –Interpretation of the wave function –Ehrenfest's theorem- Time independent Schrodinger equation - Stationary states –– Linear vector space – Linear operator – Eigen functions and Eigen Values – Hermitian Operator – Postulates of Quantum Mechanics – Simultaneous measurability of observables – General Uncertainty relation.
II	**GENERAL FORMALISM:** Dirac notation – Equations of motions – Schrodinger representation – Heisenberg representation – Interaction representation –Momentum representation – Symmetries and conservation laws: Conservation of linear momentum, Energy and Angular momentum – Parity conservation and time reversal.
III	**ONE DIMENSIONAL AND THREE DIMENSIONAL ENERGY EIGEN VALUE PROBLEMS:** Square – well potential with rigid walls – Square well potential with finite walls – Square potential barrier – Alpha emission – Bloch waves in a periodic potential – Kronig-Penny square – well periodic potential – Linear harmonic oscillator: Operator method – Particle moving in a spherically symmetric potential – System of two interacting particles – Rigid rotator– Hydrogen atom.

IV	**APPROXIMATION METHODS:** Time independent perturbation theory: Non-degenerate energy levels – Ground state of Helium atom – First order Stark effect in Hydrogen atom – Degenerate energy levels - Excited state of Hydrogen atom- Degnarate case: Zeeman effect- variation method - WKB approximation – Connection formulae (no derivation) –Application of WKB method: Barrier penetration – Alpha emission.
V	**ANGULAR MOMENTUM:** The Eigenvalue spectrum– Ladder operators– Matrix representation of J – Spin angular momentum – Angular momentum operator in position representation - Addition of angular momenta – CG Coefficients – Angular momentum commutation relations – Eigen values of J^2 and Jz - Eigenvalues of J+ and J- - Eigenvalues of JX and JY - Spin angular momentum - Pauli's exclusion principle.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Demonstrates a clear understanding of the basic postulates of quantum mechanics which serve to formalize the rules of quantum Mechanics
CO 2	Is able to apply and analyze the Schrodinger equation to solve one dimensional problems and three dimensional problems
CO 3	Can discuss the various representations, space time symmetries and formulations of time evolution
CO 4	Can formulate and analyze the approximation methods for various quantum mechanical problems
CO 5	To apply non-commutative algebra for topics such as angular and spin angular momentum and hence explain spectral line splitting.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2nd 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. SL Gupta and ID Gupta, Advanced Quantum Theory and Fields, 1st Edition, S.Chand& Co., New Delhi, 1982.
5. A. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, 4thEdition, Macmillan, India, 1984.

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.
5. V. Devanathan, Quantum Mechanics, 2nd edition, Alpha Science International Ltd, Oxford, 2011.

Web Sources:

1. http://research.chem.psu.edu/lxjgroup/download_files/chem565c7.p df
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_Lecture s/Lecture_ 1.pdf
5. https://theory.physics.manchester.ac.uk/~xian/qm/chapter3.pdf

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	3	3	2	3	2
CO 2	3	3	3	3	3	3	3	2
CO 3	2	3	3	2	3	2	3	2
CO 4	3	3	3	3	3	2	3	3
CO 5	3	3	3	2	3	3	3	3
Weightage	14	15	15	13	15	12	15	12
Weighted percentage of course contribution to POS	2.8	3	3	2.6	3	2.4	3	2.4

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	2	3	3	2	3
CO4	3	3	3	3	3
CO5	3	3	3	2	3
Weightage	14	15	13	13	15
Weighted percentage of Course Contribution to PSOs	2.8	3	2.6	2.6	3

Strong-3 M-Medium-2 L-Low-1

General Physics and Electronics Experiments – II

Title of the Course	General Physics And Electronics Experiments – II						
Course Type	CORE - VI - Lab – 2						
Year	I	Semester	II	Credits	4	Course Code	24PMPHL2
Instructional Hours Per week	Lecture	Tutorial			Lab Practice		Total
	-	--			6		6

Learning Objectives	
LO1	To understand the concept of mechanical behavior of materials and calculation of same using appropriate equations.
LO2	To analyze the magnetic properties of materials.
LO3	To analyze the optical and electrical properties of materials.
LO4	To observe the applications of FET and UJT and also learn about Combinational Logic Circuits and Sequential Logic Circuits
LO5	To study the different applications of operational amplifier circuits.

EXPERIMENTS

(Choose any SIX experiments from Part A and SIX from Part B)

PART A : General Physics Experiments -II

1. Determination of Young's modulus and Poisson's ratio by Elliptical fringes
2. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
3. B-H curve - Formation and tracing magnetic hysteresis loop and determination of energy loss for the given specimen.
4. Measurement of Magnetic Susceptibility by Guoy's method
5. Formation of acoustic grating in a given liquid and determination of velocity of ultrasonic wave in the liquid and compressibility of liquid. (Ultrasonic diffraction)
6. Determination of Thickness of thin film using Michelson Interferometer.
7. Determination of Refractive index of different liquids using diode Laser/ He – Ne Laser
8. Determination of Numerical Apertures and Acceptance angle, attenuation of optical fibers
9. Equipotential lines and electric field mapping for electrodes of different shapes.
10. Determination of Mutual Inductance and coefficient of coupling for the given pair of coils using Heaviside Bridge method
11. Hall Effect – determination of Hall coefficient, carrier concentration and mobility
12. Temperature coefficient of a thermistor using Carry Foster Bridge.

PART B : Electronics Experiments -II

1. Determination of V-I Characteristics and efficiency of solar cell.
2. Construction of a relaxation oscillator using UJT, measuring the frequency of oscillation fordifferent RC values and comparing it with the theoretical value.
3. Modulus counter using IC 7490 and seven segment display using IC 7447 / IC 7448
4. Solving simultaneous equations using IC 741 / IC LM324
5. Study of Op-Amp –Active filters: Low pass, High pass and Band pass filters
6. Construction of Current to Voltage and Voltage to Current Convertor using IC 741
7. Construction of square wave generator using IC 555 and VCO using 555.
8. Code Conversion: BCD to Excess- 3 and Excess 3 to BCD.
9. Study of Binary Ripple Counter using IC 74393 and LEDs.
10. Construction of series voltage regulator and its characteristics.
11. Construction of Shift register and Ring counter using IC 7476 /IC 7474
12. Construction of Schmitt trigger circuit using IC555 for a given hysteresis – Application as squarer

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Understand the strength of material using Young's modulus
CO 2	Acquire knowledge of thermal behavior of the materials
CO 3	Understand theoretical principles of magnetism through the experiments.
CO 4	Acquire knowledge about arc spectrum and applications of laser
CO 5	Improve the analytical and observation ability in Physics Experiments

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition.
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. 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
4. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
5. Electronic Laboratory Primer a design approach, S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	2	3	2	2	2	1
CO 2	2	2	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3
CO 4	3	2	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	2	2
Weightage	13	12	14	15	15	15	13	12
Weighted percentage of course contribution to POS	2.6	2.4	2.8	3	3	3	2.6	2.4

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	2	3	3	3
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3
Weightage	13	12	14	15	14
Weighted percentage of Course Contribution to PSOs	2.6	2.4	2.8	3	2.8

Strong-3 M-Medium-2 L-Low-1

Physics for Competitive Examinations

Title of the Course	**Physics For Competitive Examinations**						
Paper Number	**Skill Enhancement Course - I**						
Year	**I**	**Semester**	**II**	**Credits**	**2**	**Course Code**	**24PSPH21**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	2	**2**	**--**	**4**

Learning Objectives	
LO1	To develop the basics of physical principles and the mathematical background important to general mechanics and properties of matter.
LO2	To recollect the ideas of heat and thermodynamics
LO3	Formulation of the concepts of reflection, refraction in optics and longitudinal, transverse waves in sound.
LO4	To explain the formalism of electricity and magnetism
LO5	To discuss the concepts in modern physics

UNIT	**CONTENTS**
I	**GENERAL MECHANICS AND PROPERTIES OF MATTER:** Physical quantities - SI system of units - dimensions - scalars and vectors (Concepts) - Newton's equations of motion - impulse - principle of conservation of linear momentum - projectile motion - Kepler's laws - Newton's law of gravitation - acceleration due to gravity - escape velocity - angular momentum - banking of roads - simple harmonic motion – viscosity - surface Tension.
II	**HEAT AND THERMO DYNAMICS:** Different scales of temperatures - thermal expansions - calorimetry - specific heat - latent heat - triple point - transmission of heat - heat conductivity - Black body radiation - Stefan Boltzmann law - Wien's displacement law - Gas equation - Boyle's law - Charle's law - Law of equipartition of energy.

III	**LIGHT AND SOUND:** Reflection and refraction - Snell's law - total internal reflection – polarization - Brewster's Law - Huygen's principle – Young's double slit interference and single slit diffraction - longitudinal and transverse waves - velocity of sound - Newton's formula, Laplace correction, effects of pressure - beats - laws of vibrating strings - open and closed organ pipes - resonance.
IV	**ELECTRICITY AND MAGNETISM:** Coulomb's Law - Electric field due to charged particles: a point charge, a dipole, a line of charge - electric flux - Gauss' law and applications – Biot- Savart law, magnetic field due to a current in: a long straight wire, a circular arc of wire - Ampere's Law - magnetic field outside and inside a long straight wire - solenoids and toroids - Faraday's laws and Lenz's law
V	**MODERN PHYSICS:** Postulates of Einstein's theory of relativity - Galilean and Lorentz transformation - time dilation - length contraction - Planck's radiation - photoelectric effect - Compton shift, matter waves - Bohr's atomic theory. Nuclear properties - binding energy and mass defect -radioactive decay - alpha decay, beta decay and gamma decay - Radioactive dating.

Course Outcomes:

Course Outcomes: CO	**On completion of this course the student will be able to**
CO1	acquire the knowledge of the fundamental concept of physics
CO2	understand the concepts of fundamental physics
CO3	apply the concept of physics to solve various problems
CO4	strengthen an appropriate problem-solving approach and assess a step to describe the quantitative analysis.
CO5	evaluate the results of new analytical problems and develop a correct solutions or conclusions

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. J. Walker, D. Halliday, R. Resnick, Fundamentals of Physics, 10th Edition, Wiley, United states of America, 2007.
2. H.C Verma, Concept of Physics, (Volume I), 1st Edition, Bharati Bhawan Publishers & Distributors, New Delhi, 2008.
3. H.C Verma, Concept of Physics, (Volume II), 1st Edition, Bharati Bhawan Publishers & Distributors, New Delhi, 2008.

Reference books:

1. Michael Nelkon, Philip Parker, Advanced Level Physics, 7th Edition, CBS Publishers, India, 1995
2. D. Young Hugh, A. Freedman Roger, University Physics with Modern Physics, 14th Edition, Pearson Education, India, 2017.

Web resources:

1. https://hcverma.in/

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	2	2	2	2	3	2
CO 2	3	3	2	2	3	2	3	2
CO 3	3	3	2	2	3	2	3	2
CO 4	3	3	2	2	3	2	3	3
CO 5	3	3	2	2	3	2	3	3
Weightage	15	15	10	10	14	10	15	12
Weighted percentage of course contribution to POS	3	3	2	2	2.8	2	3	2.4

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1
CO2	3	2	2	2	3
CO3	2	3	3	2	1
CO4	1	3	3	2	1
CO5	1	3	3	2	1
Weightage	10	13	13	9	7
Weighted percentage of Course Contribution to PSOs	2	2.6	2.6	1.8	1.4

Strong-3 M-Medium-2 L-Low-1

Advanced Optics

Title of the Course	**Advanced Optics**						
Course Type	**ELECTIVE - III**						
Year	**I**	**Semester**	**II**	**Credits**	**3**	**Course Code**	**24PEPH21**
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		3	**1**	**--**		**4**	

Learning Objectives	After studying this topic, students should be able to
LO1	To know the concepts behind polarization and could pursue research work on application aspects of laser
LO2	To impart an extensive understanding of fiber and non-linear optics
LO3	To study the working of different types of LASERS
LO4	To differentiate first and second harmonic generation
LO5	Learn the principles of magneto-optic and electro-optic effects and its applications
UNIT	**CONTENTS**
I	**POLARIZATION AND DOUBLE REFRACTION:** Classification of polarization – Transverse character of light waves – Polarizer and analyzer – Malu's law – Production of polarized light – Wire grid polarizer and the polaroid – Polarization by reflection – Polarization by double refraction – Polarization by scattering – The phenomenon of double refraction – Normal and oblique incidence – Interference of polarized light: Quarter and half wave plates – Analysis of polarized light – Optical activity
II	**LASERS:** Basic principles – Spontaneous and stimulated emissions – Components of the laser – Resonator and lasing action – Types of lasers and its applications - Solid state lasers – Ruby laser – Nd:YAG laser – gas lasers – He-Ne laser - CO_2 laser – Chemical lasers – HCl laser – Semiconductor laser
III	**FIBER OPTICS:** Introduction – Total internal reflection – The optical fiber – Glass fibers – The coherent bundle – The numerical aperture – Attenuation in optical fibers – Single and multi-mode fibers – Pulse dispersion in multimode optical fibers – Ray dispersion in multimode step index fibers – Parabolicindex fibers – Fiber-optic sensors: precision displacement sensor – Precision vibration sensor
IV	**NON-LINEAR OPTICS:** Basic principles – Harmonic generation – Second harmonic generation – Phase matching – Third harmonic generation – Optical mixing – Parametric generation of light – Self-focusing of light

V	**MAGNETO- OPTICS AND ELECTRO-OPTICS:** Magneto-optical effects – Zeeman effect – Inverse Zeeman effect – Faraday effect – Voigt effect – Cotton-mouton effect – Kerr magneto optic effect – Electro-optical effects – Stark effect – Inverse stark effect – Electric double refraction – Kerr electro-optic effect – Pockels electro optic effect

Course Outcomes:

Course Outcomes: CO	**On completion of this course the student 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
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. B. B. Laud, 2017, Lasers and Non – Linear Optics, 3rd Edition, New Age International (P) Ltd.
2. AjoyGhatak, 2017, Optics, 6th Edition, McGraw – Hill Education Pvt. Ltd.
3. William T. Silfvast, 1996, Laser Fundamentals Cambridge University Press, New York
4. J. Peatros, Physics of Light and Optics, a good (and free!) electronic book
5. 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– itapplications.php
4. https://www.youtube.com/watch?v=0kEvr4DKGRI
5. http://optics.byu.edu/textbook.aspx

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	3	3	3	3
CO 2	3	3	3	2	3	3	3	3
CO 3	3	3	3	2	3	3	3	3
CO 4	3	3	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	3
Weightage	10	15	15	12	15	15	13	15
Weighted percentage of course contribution to POS	2	3	3	2.4	3	3	3	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	13	15
Weighted percentage of Course Contribution to PSOs	3	3	3	2.6	3

Non Linear Dynamics

Title of the Course	**Non Linear Dynamics**						
Course Type	**ELECTIVE - III**						
Year	**I**	**Semester**	**II**	**Credits**	**3**	**Course Code**	**24PEPH22**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	3	**1**	**--**	**4**

Learning Objectives

After studying this topic, students should be able to

LO1	To school the students about the analytical and numerical techniques of nonlinear dynamics.
LO2	To make the students understand the concepts of various coherent structures.
LO3	To train the students on bifurcations and onset of chaos.
LO4	To educate the students about the theory of chaos and its characterization.
LO5	To make the students aware of the applications of solitons, chaos and fractals.

UNIT	**CONTENTS**
I	**GENERAL:** Linear waves-ordinary differential equations(ODEs)-Partial differential equations(PDEs)- Methods to solve ODEs and PDEs.- Numerical methods – Linear and Nonlinear oscillators-Nonlinear waves-Qualitative features
II	**COHERENT STRUCTURES:** Linear and Nonlinear dispersive waves - Solitons – KdB equation – Basic theory of KdB equation –Ubiquitous soliton equations – AKNS Method, Backlund Transformation, Hirotabilinearization method - Perturbation methods- Solitons in Optical fibres - Applications.
III	**BIFURCATIONS AND ONSET OF CHAOS:** One dimensional flows – Two dimensional flows – Phase plane – Limit cycles – Simple bifurcations – Discrete- Dynamical system - Logistic Map– Equilibrium points and their stability – Strange attractors – Routes to chaos.
IV	**FRACTALS:** Self-similarity - Properties and examples of fractals - Fractal dimension - Construction and properties of some fractals - Middle one third cantor set - Koch curve - Sierpinski triangle – Julia set – Mandelbrot set – Applications of fractals.
V	**APPLICATIONS:** Soliton based communication systems – Solition based computation – Synchronization of chaos – Chaos based communication – Cryptography – Image processing – Stochastic – Resonance – Chaos based computation – Time Series analysis.

Course Outcomes:

Course Outcomes: CO	On completion of this course the student will be able to
CO1	Gain knowledge about the available analytical and numerical methods to solve various nonlinear systems.
CO2	Understand the concepts of different types of coherent structures and their importance in science and technology.
CO3	Learn about simple and complex bifurcations and the routes to chaos
CO4	Acquire knowledge about various oscillators, characterization of chaos and fractals.
CO5	To analyze and evaluate the applications of solutions in telecommunication, applications of chaos in cryptography, computations and that of fractals.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. M.Lakshmanan and S.Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns.Springer, 2003.
2. A.Hasegawa and Y.Kodama, Solitons in Optical Communications. Oxford Press, 1995.
3. Drazin, P. G. Nonlinear Systems. Cambridge University Press, 2012. ISBN: 9781139172455.
4. Wiggins, S. Introduction to Applied Nonlinear Dynamical Systems and Chaos. Springer, 2003. ISBN: 9780387001777.
5. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014. ISBN: 9780813349107.

Reference books:

1. G.Drazin and R.S.Johnson. Solitons: An Introduction. Cambridge University Press, 1989.
2. M.Lakshmanan and K.Murali. Chaos in Nonlinear Oscillators. World Scientific, 1989.
3. S.Strogatz**.** Nonlinear Dynamics and Chaos. Addison Wesley, 1995.
4. Hao Bai-Lin, Chaos (World Scientidic, Singapore, 1984).
5. Kahn, P. B., Mathematical Methods for Scientists & Engineers (Wiley, NY, 1990)

Web resources:
1. https://www.digimat.in/nptel/courses/video/108106135/L06.html 2. http://digimat.in/nptel/courses/video/115105124/L01.html 3. https://www.digimat.in/nptel/courses/video/108106135/L01.html 4. http://complex.gmu.edu/neural/index.html 5. https://cnls.lanl.gov/External/Kac.php

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	2	1	2	2
CO 2	3	2	2	2	2	2	2	2
CO 3	2	2	2	2	2	2	2	2
CO 4	2	2	2	2	2	1	2	2
CO 5	1	2	2	2	2	2	2	2
Weightage	11	11	11	10	10	8	10	10
Weighted percentage of course contribution to POS	2.2	2.2	2.2	2	2	1.6	2	2

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	2
CO5	1	2	2	2	2
Weightage	11	11	11	10	10
Weighted percentage of Course Contribution to PSOs	2.2	2.2	2.2	2	2

Strong-3 M-Medium-2 L-Low-1

Physics of Nano Science and Technology

Title of the Course	Physics of Nano Science and Technology						
Course Type	ELECTIVE - III						
Year	I	Semester	II	Credits	3	Course Code	24PEPH23

Instructional Hours per week	Lecture	Tutorial	Lab Practice	Total
	3	1	--	4

Learning Objectives	
LO1	Physics of Nanoscience and Technology is concerned with the study, creation, manipulation and applications at nanometer scale.
LO2	To provide the basic knowledge about nanoscience and technology.
LO3	To learn the structures and properties of nanomaterials.
LO4	To acquire the knowledge about synthesis methods and characterization techniques
LO5	To acquire the knowledge about its applications.

UNIT	CONTENTS
I	**FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY:** Fundamentals of NANO – Historical Perspective on Nanomaterial and Nanotechnology – Classification of Nanomaterials – Metal and Semiconductor Nanomaterials - 2D, 1D, 0D nanostructured materials - Quantum dots – Quantum wires – Quantum wells - Surface effects of nanomaterials.
II	**PROPERTIES OF NANOMATERIALS:** Physical properties of Nanomaterials: Melting points, specific heat capacity, and lattice constant - Mechanical behavior:Elastic properties – strength - ductility - superplastic behavior - Optical properties: - Surface Plasmon Resonance – Quantum size effects - Electrical properties - Conductivity, Ferroelectrics and dielectrics - Magnetic properties – super para magnetism – Diluted magnetic semiconductor (DMS).

III	**SYNTHESIS AND FABRICATION:** Physical vapour deposition - Chemical vapour deposition - sol-gel – Wet deposition techniques - electrochemical deposition method – Plasma arching - Electrospinning method - ball milling technique - pulsed laser deposition - Nanolithography: photolithography – Nanomanipulator.
IV	**CHARACTERIZATION TECHNIQUES:** Powder X-ray diffraction – X-ray photoelectron spectroscopy (XPS) – UV-visible spectroscopy – Photoluminescence – Scanning electron microscopy (SEM) – Transmission electron microscopy (TEM) – Scanning probe microscopy (SPM) – Scanning tunneling microscopy (STM) – Vibrating sample Magnetometer.
V	**APPLICATIONS OF NANOMATERIALS:** Sensors: Nanosensors based on optical and physical properties - Electrochemical sensors – Nano-biosensors. Nano Electronics: Nanobots - display screens - GMR read/write heads - Carbon Nanotube Emitters – Photocatalytic application: Air purification, water purification -Medicine: Imaging of cancer cells – biological tags - drug delivery - photodynamic therapy - Energy: fuel cells – rechargeable batteries - supercapacitors - photovoltaics.

Course Outcomes:

Course Outcomes: CO	On completion of this course the student 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.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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 resources:

1. http://www.its.caltec.edu/feyman/plenty.html
2. http://www.library.ualberta.ca/subject/nanoscience/guide/index.cf m
3. http://www.understandingnano.com
4. http://www.nano.gov
5. http://www.nanotechnology.com

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	1	1	3	3
CO 2	3	3	3	2	1	1	3	3
CO 3	3	3	2	2	1	1	3	3
CO 4	3	3	3	2	1	1	3	3
CO 5	3	3	2	2	1	1	3	3
Weightage	15	15	13	10	5	5	15	15
Weighted percentage of course contribution to POS	3	3	2.8	2	1	1	3	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	1
CO2	3	3	3	2	1
CO3	3	3	2	2	1
CO4	3	3	3	2	1
CO5	3	3	2	2	1
Weightage	15	15	13	10	5
Weighted percentage of Course Contribution to PSOs	3	3	2.6	2	1

Strong-3 M-Medium-2 L-Low-1

Microprocessor 8085 and Microcontroller 8051

Title of the Course	**Microprocessor 8085 and Microcontroller 8051**						
Course Type	**ELECTIVE - IV**						
Year	**I**	**Semester**	**II**	**Credits**	**3**	**Course Code**	**24PEPH24**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	3	**1**	**--**	**4**

Learning Objectives

LO1	To provide an understanding of the architecture and functioning of microprocessor 8085
LO2	To provide the methods of interfacing I/O devices and memory to microprocessor and introduce 8085 programming
LO3	To introduce 8051 Microcontroller and provide the architecture of microcontroller 8051
LO4	To introduce instruction set and assembly language programming of microcontroller 8051
LO5	To acquire the knowledge about microcontroller 8051 interfacing applications
UNIT	**CONTENTS**
I	**8085 ARCHITECTURE AND PROGRAMMING:** Functional Building Blocks of a Processor - 8085 Pinout - Hardware Architecture, Bus structure- Memory organization - data transfer concepts–Interrupts- Instruction set- Addressing Modes-Assembly Language Programs-subroutines- Timing Diagrams.
II	**MEMORY I/O PERIPHERAL DEVICES INTERFACING AND APPLICATIONS:** Memory Interface – memory mapped I/O & I/O mapped I/O- Generating Control Signals – Interfacing 2KX8 EPROM – 2KX8 RAM -Interfacing I/O ports to 8085-Hand shake signals - PPI8255-Interfacing 8255 to 8085-LED Interface- seven segment display interface - Programmable DMA controller- Programmable counter /interval timer.
III	**8051 MICROCONTROLLER:** Introduction – Features of 8051 - Pin-out of 8051- architecture - PSW and Flag Bits, Register Banks and Stack, IO Ports Usage - Special Function Registers and their uses -Interrupt Structure- Interrupt Enable Register in 8051-Interrupt Priority Register in 8051- Software Generated Interrupts Register -Internal memory (RAM & ROM) Organization-External Memory.

IV	**8051 INSTRUCTION SET AND ASSEMBLY LANGUAGE PROGRAMMING:** Instruction Set and Addressing modes: Data transfer instructions - Instructions to Access external data memory, external ROM / program memory, PUSH and POP instructions, Data exchange instructions – Logical instructions: byte and bit level logical operations, Rotate and swap operations – Arithmetic instructions: Flags, Incrementing and decrementing, Addition, Subtraction, Multiplication and division, Decimal arithmetic - Jump and CALL instructions: Types of Jumps - Subroutines – Assembly Language Programming.
V	**8051 INTERFACING APPLICATIONS:** Basics of Data acquisition systems – Sensors and Transducers – examples- Multiplexed Seven segment display interface – Wave form generation by interfacing DAC – Interfacing ADC –Stepper motor interface - Measurement of electrical quantities (voltage and current) – Measurement of Temperature and Strain – Interrupt programming and serial communication with 8051.

Course Outcomes:

Course outcomes:	**On completion of this course, the students will be able to: CO**
CO1	Gain knowledge of architecture and working of 8085 microprocessor.
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 microprocessor and microcontroller.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. A. NagoorKani, 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, Dhanpat Rai publications New Delhi (2016).
5. V. Vijayendran, 2005, Fundamentals of Microprocessor- 8085", 3rd Edition S.Visvanathan Pvt, Ltd.
6. 8051 Micro controller Architecture, Programming and Application by Kenneth .J. Ayala Second Edition- PRI.
7. 8051 Micro controller and Embedded System by Muhammad Ali Mazidi and Janice Gillispi Mazidi – Pearson Education Publication – 2006

Reference Books:

1. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware, Tata Mc Graw Hill Publications (2008)
2. Barry B. Brey, 1995, The Intel Microprocessors 8086/8088, 80186, 80286, 80386 and 80486, 3rd Edition, Prentice- Hall of India, New Delhi.
3. J. Uffrenbeck, "The 8086/8088 Family-Design, Programming and Interfacing, Software, Hardware and Applications", Prentice- Hall of India, New Delhi.
4. W. A.Tribel, Avtar Singh, "The 8086/8088 Microprocessors: Programming, Interfacing, Software, Hardware and Applications", PrenticeHall of India, New Delhi.

Web resources:

1. https://www.tutorialspoint.com/microprocessor/microprocessor 8085_architectu re.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/

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	3	3	3	1	1	1
CO 2	2	1	1	1	1	1	1	1
CO 3	3	3	3	3	3	1	1	1
CO 4	3	3	3	3	3	1	1	1
CO 5	3	3	3	3	3	1	1	1
Weightage	13	13	13	13	13	5	5	5
Weighted percentage of course contribution to POS	2.6	2.6	2.6	2.6	2.6	1	1	1

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	3
CO2	2	1	1	1	1
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	13	13	13	13	13
Weighted percentage of Course Contribution to PSOs	2.6	2.6	2.6	2.6	2.6

Strong-3 M-Medium-2 -Low-1

Materials Science

Title of the Course	Materials Science						
Course Type	ELECTIVE - IV						
Year	I	Semester	II	Credits	3	Course Code	24PEPH25

Instructional Hours per week	Lecture	Tutorial	Lab Practice	Total
	3	1	--	4

Learning Objectives	
LO1	To gain knowledge on optoelectronic materials
LO2	To learn about ceramic processing and advanced ceramics
LO3	To understand the processing and applications of polymeric materials
LO4	To gain knowledge on the fabrication of composite materials
LO5	To learn about shape memory alloys, metallic glasses and nanomaterials
UNIT	**CONTENTS**
I	**OPTOELECTRONIC MATERIALS:** Importance of optical materials – properties: Band gap and lattice matching – optical absorption and emission – charge injection, quasi- Fermi levels and recombination – optical absorption, loss and gain. Optical processes in quantum structures: Inter-band and intra-band transitions Organic semiconductors. Light propagation in materials – Electro-optic effect and modulation, electro-absorption modulation – exciton quenching.
II	**CERAMIC MATERIALS:** Ceramic processing: powder processing, milling and sintering – structural ceramics: zirconia, almina, silicon carbide, tungsten carbide – electronic ceramics – refractories – glass and glass ceramics
III	**POLYMERIC MATERIALS:** Polymers and copolymers – molecular weight measurement – synthesis: chain growth polymerization – polymerization techniques – glass transition temperature and its measurement – viscoelasticity – polymer processing techniques – applications: conducting polymers, biopolymers and high temperature polymers

IV	**COMPOSITE MATERIALS:** Particle reinforced composites – fiber reinforced composites – mechanical behavior – fabrication methods of polymer matrix composites and metal matrix composites – carbon/carbon composites: fabrication and applications.
V	**NEW MATERIALS**: Shape memory alloys: mechanisms of one-way and two-way shape memory effect, reverse transformation, thermo-elasticity and pseudoelasticity, examples and applications -bulk metallic glass: criteria for glass formation and stability, examples and mechanical behavior - nanomaterials: classification, size effect on structural and functional properties, processing and properties of Nano crystalline materials, single walled and multi walled carbon nanotubes.

Course Outcomes:

Course outcomes:	**On completion of this course, the students will be able to: CO**
CO1	Acquire knowledge on optoelectronic materials
CO2	Be able to prepare ceramic materials
CO3	Be able to understand the processing and applications of polymeric materials
CO4	Be aware of the fabrication of composite materials
CO5	Be knowledgeable of shape memory alloys, metallic glasses and nanomaterials

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Jasprit Singh, Electronic and optoelectronic properties of semiconductor structures, Cambridge University Press, 2007
2. P. K. Mallick. Fiber-Reinforced Composites. CRC Press, 2008.
3. V. Raghavan, 2003, Materials Science and Engineering, 4th Edition, Prentice- Hall India, New Delhi (For units 2,3,4 and 5)
4. G.K. Narula, K.S. Narula and V.K. Gupta, 1988, Materials Science, Tata McGraw-Hill
5. M. Arumugam, 2002, Materials Science, 3rd revised Edition, Anuratha Agencies

Reference Books:

1. B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday. Textbook of Nanoscience and Nanotechnology. Springer- Verlag, 2012.
2. K. Yamauchi, I. Ohkata, K. Tsuchiya and S. Miyazaki (Eds). Shape Memory and Super Elastic Alloys: Technologies and Applications, Wood head Publishing Limited, 2011.
3. Lawrence H. VanVlack, 1998. Elements of Materials Science and Engineering, 6th Edition, Second ISE reprint, Addison-Wesley.
4. H. Iabch and H. Luth, 2002, Solid State Physics – An Introduction to Principles of Materials Science, 2nd Edition, Springer.
5. D. Hull & T. W. Clyne, An introduction to composite materials, Cambridge University Press, 2008.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc20_mm02/preview
2. https://nptel.ac.in/courses/112104229
3. https://archive.nptel.ac.in/courses/113/105/113105081
4. https://nptel.ac.in/course/113/105/113105025/
5. https://eng.libretexts.org/Bookshelves/Materials Science/Supplemental Modules (Materials Science)/Electronic Properties/Lattice Vibrations
5. https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials Science)/Electronic_Properties/Lattice_Vibrations

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	3	3	2	2	2	2	1
CO 2	2	3	3	2	2	2	2	1
CO 3	2	3	2	2	2	2	2	2
CO 4	1	3	2	3	2	3	2	2
CO 5	2	3	2	2	2	2	2	2
Weightage	9	15	12	11	10	11	10	8
Weighted percentage of course contribution to POS	1.8	3	2.6	2.2	2	2.2	2	1.6

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	2
CO2	2	3	3	2	2
CO3	2	3	2	2	2
CO4	1	3	2	3	2
CO5	2	3	2	2	2
Weightage	9	15	12	11	10
Weighted percentage of Course Contribution to PSOs	1.8	3	2.4	2.2	2

Strong-3 M-Medium-2 L-Low-1

Characterizaton of Materials

Title of the Course	Characterizaton of Materials						
Course Type	ELECTIVE - IV						
Year	I	Semester	II	Credits	3	Course Code	24PEPH26

Instructional Hours per week	Lecture	Tutorial	Lab Practice	Total
	3	1	--	4

Learning Objectives	
LO1	To make the students learn some important thermal analysis techniques namely TGA, DTA, DSC and TMA.
LO2	To make the students understand the theory of image formation in an optical microscope
LO3	To make the students learn and understand the principle of working of electron microscopes and scanning probe microscopes.
LO4	To make the students understand some important electrical and optical characterization techniques for semiconducting materials.
LO5	To introduce the students the basics of x-ray diffraction techniques and some

UNIT	CONTENTS
I	**THERMAL ANALYSIS:** Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA)- cooling curves – differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters.
II	**MICROSCOPIC METHODS:** Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy - phase contrast microscopy –differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - digital holographic microscopy - oil immersion objectives - quantitative metallography - image analyzer.
III	**ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY:** SEM, EDAX, EPMA, TEM: working principle and Instrumentation – sample preparation –Data collection, processing and analysis- Scanning tunneling microscopy (STEM) - Atomic force microscopy (AFM) - Scanning new field optical microscopy.
IV	**ELECTRICAL METHODS AND OPTICAL CHARACTERISATION:** Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations. Photoluminescence – light – matter interaction – instrumentation – electroluminescence – instrumentation – Applications.
V	**X-RAY AND SPECTROSCOPIC METHODS:** Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, NQR, XPS, AES and SIMSproton induced X-ray Emission spectroscopy (PIXE) – Powder diffraction - Powder diffractometer -interpretation of diffraction patterns – indexing - phase identification - residual stress analysis - Particle size, texture studies

Course Outcomes:

Course outcomes:	On completion of this course, the students will be able to: CO
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.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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", PrenticeHall, (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, Butter worth Heinemann, (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

Mapping with Programme Outcomes:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	2	2	2	2
CO 2	3	3	3	2	2	2	2	2
CO 3	3	3	2	2	2	3	2	2
CO 4	2	2	2	3	2	3	2	2
CO 5	2	2	2	2	2	2	3	2
Weightage	10	13	12	11	10	12	11	10
Weighted percentage of course contribution to POS	2	2.6	2.4	2.2	2	2.4	2.2	2

S-Strong-3 M-Medium-2 L-Low-Level of Correlation between PSO and CO

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	2	2	2
CO4	2	2	2	3	2
CO5	2	2	2	2	2
Weightage	13	13	12	11	10
Weighted percentage of Course Contribution to PSOs	2.6	2.6	2.4	2.2	2

Strong-3 M-Medium-2 L-Low-1

Semester - III
Quantum Mechanics-II

Title of the Course		**Quantum Mechanics-II**					
Course Type		**Core - VII**					
Year	**II**	**Semester**	**III**	**Credits**	**5**	**Course Code**	**24PMPH31**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**-**	**--**		**5**	

Learning Objectives	
LO1	Formal development of the theory and the properties of angular momenta, both orbital and spin
LO2	To familiarize the students to the crucial concepts of scattering theory such as partial wave analysis and Barn approximation.
LO3	Time-dependent Perturbation theory and its application to study of interaction of an atom with the electromagnetic field
LO4	To give the students a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts
LO5	To introduce the concept of covariance and the use of Feynman graphs for depicting different interactions

Unit	Contents
I	**Scattering Theory:** Scattering amplitude – Cross sections – Born approximation and its validity – Scattering by a screened coulomb potential – Yukawa potential – Partial wave analysis – Scattering length and Effective range theory for S wave – Optical theorem – Transformation from centre of mass to laboratory frame.
II	**Perturbation Theory:** Time dependent perturbation theory – Constant and harmonic perturbations – Fermi Golden rule – Transition probability - Einstein's A and B Coefficients – Adiabatic approximation – Sudden approximation – Semi – classical treatment of an atom with electromagnetic radiation – Selection rules for dipole radiation .
III	**Relativistic Quantum Mechanics:** Klein – Gordon Equation – Charge and Current Densities – Dirac Matrices – Dirac Equation – Plane Wave Solutions – Interpretation of Negative Energy States – Antiparticles – Spin of Electron - Magnetic Moment of an Electron Due to Spin.
IV	**Dirac Equation:** Covariant form of Dirac Equation – Properties of the gamma matrices – Traces – Relativistic invariance of Dirac equation – Probability Density – Current four vector – Bilinear covariant – Feynman 's theory of positron (Elementary ideas only without propagation formalism)
V	**Classical Fields And Second Quantization:** Classical fields – Euler Lagrange equation – Hamiltonian formulation – Quantization of real and complex scalar fields – Creation, Annihilation and Number operators – Second Quantization of K-G field.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Familiarize the concept of scattering theory such as partial wave analysis and Born approximation
CO 2	Give a firm grounding in relativistic quantum mechanics, with emphasis on Dirac equation and related concepts
CO 3	Discuss the relativistic quantum mechanical equations namely, Klein-Gordon and Dirac equations and the phenomena accounted by them like electron spin and magnetic moment
CO 4	Introduce the concept of covariance and the use of Feynman graphs for depicting different interactions
CO 5	Demonstrate an understanding of field quantization and the explanation of the scattering matrix.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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. Nouredine Zettili, Quantum mechanics concepts and applications, 2nd Edition, Wiley, 2017.

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 Sources:
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

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	3	3	3	3	3
CO 2	3	3	2	3	3	3	3	3
CO 3	3	2	2	3	3	2	3	3
CO 4	2	1	1	3	3	1	2	2
CO 5	2	1	1	3	3	2	2	2
Weightage	13	10	9	15	15	11	13	13
Weighted percentage of course contribution to POS	2.6	2	1.8	3	3	2.2	2.6	2.6

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	2	3	3
CO3	3	2	2	3	3
CO4	2	1	1	3	3
CO5	2	1	1	3	3
Weightage	13	10	9	15	15
Weighted percentage of Course Contribution to PSOs	2.6	2	1.8	3	3

Strong-3 M-Medium-2 L-Low-1

Condensed Matter Physics

Title of the Course		**Condensed Matter Physics**					
Course Type		**Core - VIII**					
Year	**II**	**Semester**	**III**	**Credits**	**5**	**Course Code**	**24PMPH32**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**-**	**--**		**5**	

Learning Objectives	
LO1	To describe various crystal structures, symmetry and to differentiate different types of bonding.
LO2	To construct reciprocal space, understand the lattice dynamics and apply it to concept of specific heat.
LO3	To critically assess various theories of electrons in solids and their impact in distinguishing solids.
LO4	Outline different types of magnetic materials and explain the underlying phenomena.
LO5	Elucidation of concepts of superconductivity, the underlying theories – relate to current areas of research.

Unit	Contents
I	**Crystal Structure:** Types of lattices - Miller indices – Symmetry elements and allowed rotations - Simple crystal structures – Atomic Packing Factor- Crystal diffraction - Bragg's law – Scattered Wave Amplitude - Reciprocal Lattice (SC, BCC, FCC). Structure and properties of liquid crystals. Diffraction Conditions - Laue equations - Brillouin zone - Structure factor - Atomic form factor - Inert gas crystals - Cohesive energy of ionic crystals - Madelung constant - Types of crystal binding.
II	**Lattice Dynamics:** Lattice with two atoms per primitive cell - First Brillouin zone - Group and phase velocities - Quantization of lattice vibrations - Phonon momentum - Inelastic scattering by phonons - Debye's theory of lattice heat capacity - Thermal Conductivity - Umklapp processes.
III	**Theory Of Metals And Semiconductors:** Free electron gas in three dimensions - Electronic heat capacity - Wiedemann-Franz Law - Band theory of metals and semiconductors - Bloch theorem - Kronig-Penney model - Semiconductors - Intrinsic carrier concentration – Temperature Dependence - Mobility - Impurity conductivity – Impurity states - Hall effect - Fermi surfaces and construction - Experimental methods in Hall effect.
IV	**Magnetism:** Diamagnetism - Quantum theory of Para-magnetism - Rare earth ion -Hund's rule - Quenching of orbital angular momentum - Adiabatic demagnetization - Quantum theory of ferromagnetism - Curie point - Ferromagnetic domains - Bloch wall – Weiss Theory - Quantization - Magnons - Thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of antiferromagnetic material - Neel temperature.
V	**Superconductivity:** Experimental facts: Occurrence - Effect of magnetic fields - Meissner effect – Critical field – Critical current - Type I and II Superconductors. Theoretical Explanation: Thermodynamics of super conducting transition - London equations - Coherence length – Isotope effect - Cooper pairs –BCS Theory - Single particle tunneling - Josephson tunneling - DC and AC Josephson effects - High Temperature Superconductors – SQUIDS.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	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
CO 2	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.
CO 3	Student will be able to comprehend the heat conduction in solids
CO 4	Student will be able to generalize the electronic nature of solids from band theories.
CO 5	Student can compare and contrast the various types of magnetism and conceptualize the idea of superconductivity.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. C. Kittel, 1996, Introduction to Solid State Physics, 7th Edition, Wiley, New York.
2. Rita John, Solid State Physics, Tata Mc-Graw Hill Publication.
3. A. J. Dekker, Solid State Physics, Macmillan India, New Delhi.
4. M. Ali Omar, 1974, Elementary Solid State Physics – Principle and Applications, Addison - Wesley
5. H. P. Myers, 1998, Introductory Solid State Physics, 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 Solid State, 3rd Edition, Oxford University Press, Oxford.
3. J. M. Ziman, 1971, Principles of the Theory of Solids, Cambridge University 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 Sources:
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/ 5. https://www.brainkart.com/article/Super-Conductors_6824/

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	2	2	2	2	2
CO 2	3	2	3	2	3	2	3	3
CO 3	3	3	3	2	3	2	3	3
CO 4	2	2	2	2	2	2	2	2
CO 5	2	2	2	2	2	2	2	2
Weightage	13	11	13	10	12	10	12	12
Weighted percentage of course contribution to POS	2.6	2.2	2.6	2	2.4	2	2.4	2.4

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2
CO2	3	2	3	2	3
CO3	3	3	3	2	3
CO4	2	2	2	2	2
CO5	2	2	2	2	2
Weightage	13	11	13	10	12
Weighted percentage of Course Contribution to PSOs	2.6	2.1	2.6	2	2.4

Strong-3 M-Medium-2 L-Low

Numerical Methods and Programming in C++

Title of The Course		Numerical Methods and Programming in C++					
Course Type		Core - IX					
Year	II	Semester	III	Credits	5	Course Code	24PMPH33
Instructional Hours Per week		Lecture	Tutorial	Lab Practice		Total	
		5	-	--		5	

Learning Objectives	
LO1	To make students to understand different numerical approaches to solve a roots of equation problem.
LO2	To understand the curve fitting-Interpolation and its application to solve physical problems.
LO3	To understand the Eigen values, Differentiation and integration and also to solve problems.
LO4	To make students to understand differential equations (Ordinary and Partial).
LO5	To make students to understand Programming in C++ and also to also to write the basic program.
Unit	**Contents**
I	**Roots Of Equation:** Roots of equation: Bisection method – False position method – Newton Raphson method – Secant method – Order of convergence. Simultaneous Equations: Existence of solutions- Basic Gauss elimination method – Gauss Jacobi iteration method – Gauss Seidal iteration method – Inverse of a matrix using Gauss elimination method .
II	**Curve Fitting – Interpolation:** Curve fitting: Method of least squares – straight line, fitting a parabola, fitting $y = ax^n$, $y = ae^{bx}$ type curves – **Interpolation:** Polynomial Interpolation – Lagrange polynomial – Newton polynomial - Forward and Backward differences – Gregory Newton forward and backward interpolation formula for equal intervals – Divided difference – properties of divided differences – Newton's divided differences formula – Lagrange's interpolation formula for unequal interval
III	**Eigen Values, Differentiation And Integration: Eigenvalues:** Power method to find dominant Eigenvalue - Jacobi method **Numerical differentiation**: Numerical differentiation – Formulae for derivatives – Taylors Series Method - Forward backward differences and central difference formula **Numerical Integration**: Newton – cotes formula – Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, – Error estimates in trapezoidal and Simpson's rule – Monte Carlo Method.

IV	**Differential Equations: Ordinary differential equation:** Solution by Taylor's series –- Basic Euler method –Improved and Modified Euler method – Runge Kutta fourth order method – solution of simultaneous first order differential equations and second order differential equations by RK fourth order Method **Partial differential equation**: Introduction- Classification of partial differential equation of the 2nd order – Finite Difference approximations - Solution of Laplace's equation – Solution of Poisson's Equation –standard five point formula and diagonal five point formula (Jacobi and Gauss Seidal Methods).
V	**Programming in C++:** Program structure and header files - Basic data types- operators - Control Structures: decision making and looping statements. Arrays, Strings, Structures, Pointers and File handling. Application programs – Solution to Algebraic and transcendental equations by Newton Raphson Method - Charging and discharging of a condenser by Euler's Method – Radioactive Decay by Runge Kutta fourth order method - Newton's Law of cooling by Numerical differentiation.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	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.
CO 2	Relate Simultaneous linear equations and their matrix representation Distinguish between various methods in solving simultaneous linear equations.
CO 3	Understand, how interpolation will be used in various realms of physics and Apply to some simple problems Analyze the newton forward and backward interpolation
CO 4	Recollect and apply methods in numerical differentiation and integration. Assess the trapezoidal and Simpson's method of numerical integration.
CO 5	Understand the basics of C++-programming and conditional statements.

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Introductory methods of numerical analysis, S. S. Sastry, Prentice Hall of India, 2010
2. Numerical methods for mathematics, science and engineering, John H. Matthews, Prentice Hall of India, 2nd Edition, 2000
3. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods for Scientific and Engineering computation, 3 rd edition, New age international (P) Ltd, Chennai , 1998.
4. Object Oriented Programming with C++ by E. Balagurusamy, Tata McGraw-Hill , India, 4th Edition

Reference books:

1. Computer Applications in Physics, S. Chandra, M.K. Sharma, Narosa, 3rd Edition,2014
2. M. K. Venketraman, Numerical Methods in Science and Engineering 2nd Ed., National Publishing Co., Chennai (2010).
3. E. Balagurusamy, Computer Oriented Statistical and Numerical Methods, Macmillan India Ltd, New Delhi (2000).

Web Sources:

1. https://youtu.be/LbKKzMag5Rc
2. https://youtu.be/Xb9Ypn77LBo
3. https://youtu.be/FfqAIlOxkoY

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	1	1	2	3	2
CO 2	3	2	3	1	1	2	3	2
CO 3	3	2	3	1	1	2	3	2
CO 4	3	2	3	1	1	2	3	2
CO 5	3	2	3	1	1	2	3	2
Weightage	15	10	15	5	5	10	15	10
Weighted percentage of course contribution to POS	3	2	3	1	1	2	3	2

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	1	1
CO2	3	2	3	1	1
CO3	3	2	3	1	1
CO4	3	2	3	1	1
CO5	3	2	3	1	1
Weightage	15	10	15	5	5
Weighted percentage of Course Contribution to PSOs	3	2	3	1	1

Strong-3 M-Medium-2 L-Low-

Advanced Physics Experiments – I and Microprocessor 8085 & Microcontroller 8051 Programming

Title of the Course	**Advanced Physics Experiments – I and Microprocessor 8085 & Microcontroller 8051 Programming**						
Course Type	**Core – X - Lab – 3**						
Year	**II**	**Semester**	**III**	**Credits**	**4**	**Course Code**	**24PMPHL3**
Instructional Hours Per week	**Lecture**	**Tutorial**			**Lab Practice**		**Total**
	--	**--**			**6**		**6**

Learning Objectives	
LO1	To make students to understand different concepts of physics.
LO2	To study the Rydberg constant using Hydrogen Vapor lamp source and Magneto resistance of the given material.
LO3	To Study the characteristic of Photo Transistor
LO4	To study characteristics of Solar cell
LO5	To understand the basics of microprocessor and microcontroller programming.

Experiments

Advanced Physics Experiments – I and Microprocessor 8085 & Microcontroller 8051 Programming

Section A (Any 6 Experiments)

1. Determination of Cauchy's Constant of the given prism – material. Obtain data by doing the Cauchy's Experiment and fitting a straight line using any software.
2. Determination of Rydberg constant using Hydrogen Vapor lamp source.
3. Determination of Magneto resistance of the given material.
4. Determination of Dielectric constant of the given liquid medium using Colpitt's oscillator or LCR circuit.
5. Study of Characteristics of a special transistor (any one).
6. Study the performance characteristics of the temperature Sensor LM35
7. Analysis of rotation and vibration spectrum /Interpretation of vibrational spectra of a given material.
8. Determination of e/k using Transistors
9. Approximate determination of Fermi Energy of Copper (Heating & Cooling method)
10. To study V-I Characteristics, Load Response, and Spectral Response of Photovoltaic Solar Cell
11. Lab view / Pspice Simulation: Designing and simulating an Astable Multivibrator using a 555 Timer for the given frequency.
12. Lab view / Pspice Simulation: Simulation of a Zener diode characteristics and voltage Regulator.

Section B : Microprocessor 8085 and Microcontroller 8051 Programming

(Any 6 Experiments)

All Programs should contain Algorithms and Flowcharts 8085 Microprocessor Programs

1. **Arithmetic Operations**
   a) Addition and Subtraction of two 8 bit numbers
   b) Multiplication of two 8 bit numbers –16-bit result.
   c) Division of 16 bit number by 8 bit number.

2. **Data Manipulation**
   a) Arrange the given data items in Ascending or Descending order
   b) Finding the Minimum or Maximum value in the given data set.
   c) Search of a given character/number in the given data set.

3. **System Call and Rolling a character**
   a) Calculation of time delay for a given interval.
   b) Roll a given character from Left to Right / Right to Left on the 7 segment displays with the specified time interval.

4. **ADC Interfacing and Conversion**
   a) Interfacing ADC with 8085 – ADC chip Block diagram – 8085 - ADC interfacing diagram
   b) Conversion of analog input to digital – Resolution – Graph between input and output.

5. **DAC interfacing and Wave form generation**.

Interfacing DAC with 8085 – DAC Chip Block diagram – 8085 - DAC - 8085 interfacing diagram. Wave Form Generation using DAC.

a) Square wave with the specified period T

b) Rectangular Wave with Specified T_H and T_L

c) Ramp Wave

8051 Programs using Trainer Kit or Using Simulator - MCU8051 IDE (Freeware)

6. Data Transfer Programming

a) Write an assembly language program to transfer N bytes of data from location A: XX H to location B: YY H

b) Write an assembly language program to exchange N bytes of data at location A: XX H and at location B: YY H.

7. Data Manipulation

a) Write an assembly language program to find the largest element in a given array of N bytes at location 0400h. Store the largest element at location 0500h.

b) Write an assembly language program to count number of ones and zeros in an eight bit number.

8. Arithmetic Programming

a) Write an assembly language program to perform the addition of two 16-bit numbers.

b) Write an assembly language program to perform the subtraction of two 16-bit numbers.

c) Write an assembly language program to perform the multiplication of two 8-bit numbers.

d) Write an assembly language program to find the square of a given number N.

9. Code Conversion

a) Write an assembly language program to convert a BCD number into ASCII.

b) Write an assembly language program to convert a ASCII number into Decimal.

c) Write an assembly language program to convert a decimal number into ASCII.

d) Write an assembly language program to convert a binary (hex) number into decimal.

e) BCD to 7 Segment Code

10. Counter

Write an assembly language program to implement a decimal counter and show the count on the 7segment display virtual hardware available in the simulator. Write and use a proper delay routine.

Course Outcomes:

CO	Course outcomes – on completion of this course, the students will be able to
CO 1	Determination of some physical constants using specialized instruments
CO 2	Spectral data analysis techniques and interpretation
CO 3	Simulation of some physical experiments using specialized software
CO 4	Hands on experience with microprocessor Programming
CO 5	Hands on experience with Microcontroller Programming

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition.
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. 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
4. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
5. Electronic Laboratory Primer a design approach, S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	2	3	2	2	2	1
CO 2	2	2	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3
CO 4	3	2	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	2	2
Weightage	14	12	14	15	14	14	13	12
Weighted percentage of course contribution to POS	2.8	2.4	2.8	3	2.8	2.8	2.6	2.4

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	2	3	3	3
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3
Weightage	14	12	14	15	14
Weighted percentage of Course Contribution to PSOs	2.8	2.4	2.8	3	2.8

Sewage and Waste Water Treatment and Reuse

Title of the Course	**Sewage And Waste Water Treatment and Reuse**						
Course Type	**Skill Enhancement Course - II**						
Year	**II**	**Semester**	**III**	**Credits**	**2**	**Course Code**	**24PSPH31**
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		2	**2**	**--**		**4**	

Learning Objectives	
LO1	To gain basic knowledge in sewage and waste water Treatment procedures
LO2	To gain industry exposure and be equipped to take up job.
LO3	To harness entrepreneurial skills.
LO4	To analyze the status of sewage and waste water management in the nearby areas.
LO5	To sensitize the importance of healthy practices in waste water management.

Unit	Contents
I	**Recovery & Reuse Of Water:** Recovery & Reuse of water from Sewage and Waste water: Methods of recovery: Flocculation - Sedimentation - sedimentation with coagulation - Filtration - sand filters - pressure filters - horizontal filters - vector control measures in industries - chemical and biological methods of vector eradication
II	**Disinfection:** Disinfection: Introduction to disinfection and sterilization: Disinfectant - UV radiation - Chlorination - Antisepsis - Sterilant - Aseptic and sterile Bacteriostatic and Bactericidal - factors affecting disinfection.
III	**Chemical Disinfection:** Chemical Disinfection: Introduction - Theory of Chemical Disinfection Chlorination Other Chemical Methods - Chemical Disinfection Treatments Requiring - Electricity - Coagulation/Flocculation Agents as Pretreatment Disinfection By-Products(DBPs)
IV	**Physical Disinfection:** Physical Disinfection: Introduction - Ultraviolet Radiation - Solar Disinfection - Heat Treatment - Filtration Methods - Distillation Electrochemical Oxidation Water Disinfection by Microwave Heating.
V	**Reuse Management**: Water uses -Agriculture, Drip irrigation, Sprinkler irrigation and check dams. Industries- coolant, various process Drinking, washing, Sanitation, gardening, Recreation- waterfalls, water sports, Environment sustainability –conservation and reuse management. **Industrial visit – data collection and analysis - presentation**

Course Outcomes:

Course Outcomes: CO	On completion of this course the student 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

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Drinking water and disinfection technique, Anirudhha Balachandra. CRC press (2013)
2. Design of Water and Wastewater Treatment Systems (CV-424/434), Shashi Bushan,)
3. Integrated Water Resources Management, Sarbhukan M M, CBS PUBLICATION (2013)
4. C.S. Rao, Environmental Pollution Control Engineering, New Age International, 2007
5. S.P. Mahajan, Pollution control in process industries, 27th Ed. Tata McGraw Hill Publishing Company Ltd., 2012.

Reference books:

1. Handbook of Water and Wastewater Treatment Plant Operations, Frank. R Spellman, CRC Press, 2020
2. Wastewater Treatment Technologies, MritunjayChaubey, Wiley, 2021.
3. Metcalf and Eddy, Wastewater Engineering, 4th ed., McGraw Hill Higher Edu., 2002.
4. W. Wesley Eckenfelder, Jr., Industrial Water Pollution Control, 2nd Edn., McGraw Hill Inc., 1989
5. Lancaster, Green Chemistry: An Introductory Text, 2nd edition, RSC publishing, 2010.

Web resources:
1.https://www.google.co.in/books/edition/Drinking_Water_DisinfectionTechniques/HVbNBQAAQBAJ?hl=en 2. https://www.meripustak.com/Integrated-Solid-Waste- Management-Engineering-Principles-And- Management-Issues-125648? 3. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsACgM0iVpismAJN93CHA1sX6NuNeOKLXfQJjxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 4. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsAC-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJjxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 5. https://www.amazon.in/Design-Wastewater-Treatment-Systems-CV-424/dp/B00IG2PI6K/ref=asc_df_B00IG2PI6K/?tag=googleshopmob

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	3	3	3	2	3	2
CO 2	2	3	2	2	3	3	2	3
CO 3	2	2	2	2	2	3	3	3
CO 4	3	2	3	3	2	3	3	3
CO 5	2	2	2	2	3	3	2	2
Weightage	12	11	12	12	13	14	13	13
Weighted percentage of course contribution to POS	2.4	2.2	2.4	2.4	2.6	2.8	2.6	2.6

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	2	3	2	2	3
CO3	2	2	2	2	2
CO4	3	2	3	3	2
CO5	2	2	2	2	3
Weightage	12	11	12	12	13
Weighted percentage of Course Contribution to PSOs	2.4	2.2	2.4	2.4	2.6

Spectroscopy

Title of the Course	Spectroscopy						
Course Type	Elective - V						
Year	II	Semester	III	Credits	3	Course Code	24PEPH31
Instructional Hours per week	Lecture	Tutorial	Lab Practice	Total			
	3	2	--	5			

Learning Objectives	After studying this topic, students should be able to
LO1	To comprehend the theory behind different spectroscopic methods
LO2	To know the working principles along with an overview of construction of different types of spectrometers involved
LO3	To explore various applications of these techniques in R &D.
LO4	Apply spectroscopic techniques for the qualitative and quantitative analysis of various chemical compounds.
LO5	Understand this important analytical tool

Unit	Contents
I	**Microwave Spectroscopy:** Rotational spectra of diatomic molecules - Rigid Rotor (Diatomic Molecules)-reduced mass – rotational constant - Effect of isotopic substitution - Non rigid rotator – centrifugal distortion constant- Intensity of Spectral Lines- Polyatomic molecules – linear – symmetric asymmetric top molecules - Instrumentation techniques – block diagram –Information Derived from Rotational Spectra - Problems.
II	**Infra-Red Spectroscopy:** Vibrations of simple harmonic oscillator – zero-point energy- Anharmonic oscillator – fundamentals, overtones and combinations- Diatomic Vibrating Rotator- PR branch – PQR branch- Fundamental modes of vibration of H_2O and CO_2 -Introduction to application of vibrational spectra- IR Spectrophotometer Instrumentation (Double Beam Spectrometer) – Fourier Transform Infrared Spectroscopy - Interpretation of vibrational spectra – Simple applications.
III	**Uv Spectroscopy:** Origin of UV spectra - Laws of absorption – Lambert Beer law - molar absorptivity – transmittance and absorbance - Color in organic compounds- Absorption by organic Molecule -Chromophores -Effect of conjugation on chromophores - Choice of Solvent and Solvent effect - Absorption by inorganic systems - Instrumentation - double beam UV- Spectrophotometer -Simple applications
IV	**Raman Spectroscopy:** Theory of Raman Scattering - Classical theory – molecular polarizability – polarizability ellipsoid - Quantum theory of Raman effect - rotational Raman spectra of linear molecule - symmetric top molecule – Stokes and anti-stokes line - Raman activity of H_2O and CO_2 -Mutual exclusion principle- determination of N_2O structure -Instrumentation technique and block diagram - structure determination of planar and non-planar molecules using IR - FT Raman spectroscopy- Surface Enhanced Raman Spectroscopy.
V	**Resonance Spectroscopy:** Nuclear and Electron spin- Interaction with magnetic field - Population of Energy levels - Double resonance- Chemical shift and its measurement - NMR of Hydrogen nuclei - Indirect Spin -Spin Interaction – interpretation of simple organic molecules - Instrumentation techniques of NMR spectroscopy **Electron Spin Resonance**: Basic principle –Total Hamiltonian (Direct Dipole-Dipole interaction and Fermi Contact Interaction) – Hyperfine Structure (Hydrogen atom) – ESR Spectra of Free radicals –g-factors – Instrumentation - Medical applications of ESR

Course Outcomes:

Course Outcomes: CO	On completion of this 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.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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

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, Springer Link.

Web resources:

1. 1https://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

Mapping with Programme Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	3	2	3	3	3	3
CO 2	2	2	2	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	3
CO 4	3	2	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	3
Weightage	14	12	14	14	15	15	15	15
Weighted percentage of course contribution to POS	2.8	2.4	2.8	2.8	3	3	3	3

S-Strong-3 M-Medium-2 L-Low-1

Level of Correlation between PSO and CO

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3
CO2	2	2	2	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3
Weightage	14	12	14	14	15
Weighted percentage of Course Contribution to PSOs	2.8	2.4	2.8	2.8	3

Strong-3 M-Medium-2 L-Low-1

Crystal Growth and Thin Films

Title of the Course	**Crystal Growth And Thin Films**						
Course Type	**Elective - V**						
Year	**II**	**Semester**	**III**	**Credits**	**3**	**Course Code**	**24PEPH32**
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**	**Total**		
		3	**2**	**--**	**5**		
Learning Objectives	After studying this topic, students should be able to						
LO1	To acquire the knowledge on Nucleation and Kinetics of crystal growth						
LO2	To understand the Crystallization Principles and Growth techniques						
LO3	To study various methods of Crystal growth techniques						
LO4	To understand the thin film deposition methods						
LO5	To apply the techniques of Thin Film Formation and thickness Measurement						

Unit	Contents
I	**Crystal Growth Kinetics:** Basic Concepts, Nucleation and Kinetics of growth Ambient phase equilibrium - super saturation - equilibrium of finite phases equation of Thomson - Gibbs - Types of Nucleation - Formation of critical Nucleus - Classical theory of Nucleation - Homo and heterogeneous formation of 3D nuclei - rate of Nucleation - Growth from vapour phase solutions, solutions and melts - epitaxial growth - Growth mechanism and classification - Kinetics of growth of epitaxial films
II	**Crystallization Principles:** Crystallization Principles and Growth techniques Classes of Crystal system - Crystal symmetry - Solvents and solutions - Solubility diagram - Super solubility - expression for super saturation - Metastable zone and introduction period - Miers TC diagram - Solution growth - Low and high temperatures solution growth - Slow cooling and solvent evaporation methods - Constant temperature bath as a Crystallizer.
III	**Gel, Melt And Vapour Growth:** Gel, Melt and Vapour growth techniques Principle of Gel techniques - Various types of Gel - Structure and importance of Gel - Methods of Gel growth and advantages - Melt techniques - Czochralski growth - Floating zone - Bridgeman method - Horizontal gradient freeze - Flux growth - Hydrothermal growth - Vapour phase growth - Physical vapour deposition - Chemical vapour deposition - Stoichiometry.
IV	**Thin Film Deposition Methods:** Thin film deposition methods of thin film preparation, Thermal evaporation, Electron beam evaporation, pulsed LASER deposition, Cathodic sputtering, RF Magnetron sputtering, MBE, chemical vapour deposition methods, Sol Gel spin coating, Spray pyrolysis, Chemical bath deposition.
V	**Thin Film Formation:** Thin Film Formation and thickness Measurement Nucleation, Film growth and structure - Various stages in Thin Film formation, Thermodynamics of Nucleation, Nucleation theories, Capillarity model and Atomistic model and their comparison. Structure of Thin Film, Roll of substrate, Roll of film thickness, Film thickness measurement - Interferometry, Ellipsometry, Micro balance, Quartz Crystal Oscillator techniques.

Course Outcomes:

Course Outcomes : CO	On completion of this course the student 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

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, ProfessionalCompetency, Professional Communication and Transferrable Skill

Recommended Texts:

1. V. Markov Crystal growth for beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy (2004) 2nd edition
2. A. 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.SanthanaRaghavan and P. Ramasamy, "Crystal Growth Processes", KRU Publications.
4. H.E. Buckley, 1951, Crystal Growth, John Wiley and Sons, NY
5. B.R. Pamplin, 1980, Crystal Growth, Pergman Press, London.

Web resources:
1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRjLrXp3kMtrI O8kZl1D1Jp 2. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgwcy7 KeTLUuBu3WF 3. https://www.youtube.com/playlist?list=PLADLRin7kNjG1Dlna9MDA 53CMKFHPSi9m 4. https://www.youtube.com/playlist?list=PLXHedIxbyr8xIl_KQFs_ R_oky3Yd1Emw 5. https://www.electrical4u.com/thermal-conductivity-of-metals/

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	2	1	2	1	3	2	2
CO 2	3	3	1	3	1	2	3	2
CO 3	3	2	1	3	1	2	3	3
CO 4	3	2	1	2	1	2	3	3
CO 5	2	3	3	3	1	3	3	3
Weightage	14	12	7	13	5	12	14	13
Weighted percentage of course contribution to POS	2.8	2.4	1.4	2.6	1	2.4	2.8	2.6

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	3	3	1	3	1
CO3	3	2	1	3	1
CO4	3	2	1	2	1
CO5	2	3	3	3	1
Weightage	14	12	7	13	5
Weighted percentage of Course Contribution to PSOs	2.8	2.4	1.4	2.6	1

General Relativity and Cosmology

Title of the Course	**General Relativity And Cosmology**						
Course Type	**Elective - V**						
Year	**II**	**Semester**	**III**	**Credits**	**3**	**Course Code**	**24PEPH33**
Instructional Hours per week		**Lecture**	**Tutorial**		**Lab Practice**	**Total**	
		3	**2**		**--**	**5**	
Learning Objectives							
LO1	To acquire the knowledge on Tensors						
LO2	To acquire the knowledge on Tensor field, elasticity curvature of tensor						
LO3	To give an introduction to students in the area of general relativity						
LO4	To give an introduction to students in the area of Tensor relativity						
LO5	To give an introduction to students in the area cosmology						

Unit	Contents
I	**Tensors:** Tensors in index notation - Kronecker and Levi Civita tensors - inner and outer products - contraction - symmetric and antisymmetric tensors - quotient law - metric tensors - covariant and contravariant tensors - vectors - the tangent space - dual vectors - tensors - tensor products - the Levi-Civita tensor tensors in Riemann spaces
II	**Tensors Field:** Vector-fields, tensor-fields, transformation of tensors - gradient and Laplace operator in general coordinates - covariant derivatives and Christoffel connection - Elasticity: Field tensor - field energy tensor - strain tensor tensor of elasticity- curvature tensor.
III	**General Relativity:** The spacetime interval - the metric - Lorentz transformations - space-time diagrams - world-lines - proper time - energy-momentum vector - energymomentum tensor - perfect fluids - energy-momentum conservation - parallel transport - the parallel propagator - geodesics - affine parameters - the Riemann curvature tensor - symmetries of the Riemann tensor - the Bianchi identity
IV	**Tensor In Relativity:** Ricci and Einstein tensors - Weyl tensor - Killing vectors - the Principle of Equivalence - gravitational redshift - gravitation as space-time curvature - the Newtonian limit - physics in curved space-time - Einstein's equations - the Weak Energy Condition - causality - spherical symmetry - the Schwarzschild metric - perihelion precession.
V	**Cosmology:** Expansion of the Universe - thermal history - and the standard cosmological model - Friedmann - Robertson-Walker type models of the Universe Primordial inflation and the theory of cosmological fluctuations - Theory and observations of the cosmic microwave background and of the large-scale structure of the Universe - Dark matter and dark energy - theoretical questions and observational evidence - inflation - origin of galaxies and other open problems.

Course Outcomes:

Course Outcomes : CO	On completion of this course the student 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

Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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
5. 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
5. Cosmology, Cambridge University Press 2006 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 5. https://uwaterloo.ca/applied-mathematics/future-undergraduates/what-youcan-learn-applied-mathematics/relativity-and-cosmology

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	1	3	2	3	2	2
CO 2	3	3	1	3	2	3	2	2
CO 3	3	2	1	2	1	2	1	1
CO 4	3	2	1	2	1	2	1	1
CO 5	3	2	1	2	1	2	1	1
Weightage	15	12	5	12	7	12	7	7
Weighted percentage of course contribution to POS	3	2.4	1	2.4	1.4	2.4	1.4	1.4

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	1	3	2
CO2	3	3	1	3	2
CO3	3	2	1	2	1
CO4	3	2	1	2	1
CO5	3	2	1	2	1
Weightage	15	12	5	12	7
Weighted percentage of Course Contribution to PSOs	3	2.4	1	2.4	1.4

Strong-3 M-Medium-2 L-Low-1

Semester - IV
Nuclear and Particle Physics

Title of the Course		**Nuclear and Particle Physics**					
Course Type		**Core - XI**					
Year	**II**	**Semester**	**IV**	**Credits**	**5**	**Course Code**	**24PMPH41**
Instructional Hours Per week		**Lecture**	**Tutorial**	**Lab Practice**		**Total**	
		5	**1**	**-**		**6**	

Learning Objectives	
LO1	Introduces students to the different models of the nucleus in a chronological order.
LO2	Imparts an in-depth knowledge on the nuclear force, experiments to study it.
LO3	Provides students with details of the types of nuclear reactions and their principles.
LO4	Provides students with details of nuclear decay with relevant theories.
LO5	Exposes students to the Standard Model of Elementary Particles and Higgs boson.

Unit	**Contents**
I	**Nuclear Models:** Basic properties-Liquid drop model – Weizacker mass formula – Isobaric mass parabola –Mirror Pair - Bohr Wheeler theory of fission – shell model – spin-orbit coupling – magic numbers – angular momenta and parity of ground states – magnetic moment – electric Quadrupole moment - Bohr and Mottelson collective model - Semiempirical relation.
II	**Nuclear Forces:** Nucleon – nucleon interaction – Tensor forces – properties of nuclear forces – ground state of deuteron – Exchange Forces - Meson theory of nuclear forces – Yukawa potential – Low nucleon- nucleon scattering – effective range theory – spin dependence of nuclear forces - charge independence and charge symmetry – isospin formalism.
III	**Nuclear Reactions:** Kinds of nuclear reactions – Reaction kinematics – Q-value – Partial wave analysis of scattering and reaction cross section – scattering length – Compound nuclear reactions – Reciprocity theorem – Resonances – Breit Wigner one level formula – Direct reactions - Nuclear Chain reaction – four factor formula.
IV	**Nuclear Decay:** Beta decay – Continuous Beta spectrum – Fermi theory of beta decay - Comparative Half-life –Fermi Kurie Plot – mass of neutrino – allowed and forbidden decay – neutrino physics – Helicity - Parity violation - Gamma decay – multipole radiations – Angular Correlation - internal conversion – nuclear isomerism – angular momentum and parity selection rules.

V	**Elementary Particles:** Classification of Elementary Particles – Types of Interaction and conservation laws – Families of elementary particles – Isospin – Quantum Numbers – Strangeness – Hypercharge and Quarks –SU (2) and SU (3) groups-Gell Mann matrices– Gell Mann Okuba Mass formula- Quark Model. Standard model of particle physics – Higgs boson.

Course Outcomes:

CO	**On completion of this course, the students will be able to**
CO1	Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion.
CO2	Demonstrate knowledge of fundamental aspects of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter.
CO3	Use the different nuclear models to explain different nuclear phenomena and the concept of resonances through Briet-Weigner single level formula
CO4	Analyze data from nuclear scattering experiments to identify different properties of the nuclear force.
CO5	Summarize and identify allowed and forbidden nuclear reactions based on conservation laws of the elementary particles.
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved(To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. D. C. Tayal – Nuclear Physics – Himalaya Publishing House (2011).
2. K. S. Krane – Introductory Nuclear Physics – John Wiley & Sons (2008).
3. R. Roy and P. Nigam – Nuclear Physics – New Age Publishers (1996).
4. S. B. Patel – Nuclear Physics – An introduction – New Age International Pvt Ltd Publishers (2011).
5. S. Glasstone – Source Book of Atomic Energy – Van Nostr and 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 Sources:

1. http://bubl.ac.uk/link/n/nuclearphysics.html
2. http://www.phys.unsw.edu.au/PHYS3050/pdf/Nuclear_Models.pdf
3. http://www.scholarpedia .org/article/Nuclear Forces
4. https://www.nuclear-power.net/nuclear-power/nuclear-reactions/
5. http://labman.phys.utk.edu/phys222core/modules/m12/nuclear_models.html
6. 6https://www.ndeed.org/EducationResources/HighSchool/Radiography/radioactivedec ay.html

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	3	3	2	2	2	2	2	2
CO 2	3	3	2	2	1	2	1	2
CO 3	3	3	1	2	1	2	1	1
CO 4	3	3	2	3	2	3	2	2
CO 5	3	3	2	3	2	3	2	3
Weightage	15	15	9	12	8	12	8	10
Weighted percentage of course contribution to POS	3	3	1.8	2.4	1.6	2.4	1.6	2

Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2
CO2	3	3	2	2	1
CO3	3	3	1	2	1
CO4	3	3	2	3	2
CO5	3	3	2	3	2
Weightage	15	15	9	12	8
Weighted percentage of Course Contribution to PSOs	3	3	1.8	2.4	1.6

Advanced Physics Experiments – II and Numerical Methods in C++

Title of the Course	**Advanced Physics Experiments – II and Numerical Methods in C++**						
Course Type	**Core - XII**						
Year	**II**	**Semester**	**IV**	**Credits**	**4**	**Course Code**	**24PMPHL4**
Instructional Hours Per week	**Lecture**	**Tutorial**			**Lab Practice**		**Total**
	-	**-**			**6**		**6**

Learning Objectives	
LO1	To apply theoretical knowledge through hands-on experiments in order to analyze and understand the characteristics and behaviors of various physical and electronic systems, while developing practical skills in measurement, data analysis, and circuit design.
LO2	To understand the characteristics and behaviors of various physical and electronic systems, while developing practical skills in measurement, data analysis, and circuit design.
LO3	To understand the characteristics of photo resistor.
LO4	To design the Serial Shift Registers and Encoder and Decoder Circuits using necessary
LO5	To familiarize the students with numerical methods used in problem-solving by writing programs using the high level language C++

Experiments

Advanced Physics Experiments – II and Numerical Methods in C++

Section A: Advanced Physics Experiments – II (Any Experiments)

1. Investigate the equilibrium points of the logistic map equation $X_{n+1} = aX_n (1- X_n)$ for various parameter values and initial conditions:
   a) Determine the equilibrium points for 'a' ranging from 0.5 to 2.5 with a step size of 0.1 Considering $x_0=0.1$.
   b) Explore the behavior of the logistic map for 'a' values between 3.5 and 4.0 with a step size of 0.05 for $x_0=0.2$.
   c) Analyze the dynamics near the period-doubling bifurcation point at $a\approx3.828$, Considering $x_0=0.3$.
   d) Plot x_n versus n for each scenario and generate bifurcation diagrams to visualize the system's behavior.
2. Measurement of Band gap energy of Thermistor material.
3. Examine the input-output characteristics of an ADC or DAC IC. The characteristics may include parameters such as linearity, accuracy, resolution and dynamic range.
4. Photo Conductivity Experiment:
   a) To plot the current-voltage characteristics of a CdS Photo Resistor (LDR) at constant irradiance.
   b) To measure the Photo current as a function of irradiance at constant voltage.
5. Determination of the distance between two tracks of a CD and a DVD using a laser.
6. Verification of Thevenin's theorem and Maximum power transfer theorem.
7. Study the Characteristics of a Load cell
8. Design of a Serial Shift Registers using necessary Flip-Flop ICs.
9. Design of Encoder and Decoder Circuits using necessary ICs.
10. Study of a quartz crystal (1 MHz) and construction of a Piezo-crystal Oscillator using digital inverters.
11. UV spectral data analysis for the given spectrum.
12. Simulation of satellite orbit around the earth using the universal law of gravitation in Scilab.

Section – B : Numerical Methods in C++ (Any SIX programs with Algorithm and Flow chart)

1. Algebraic and Transcendental equation.
   a) Solution of the given equations using Newton Raphson Method – manual calculation.
   b) C++ program to find the solution using N-R method and verification.

2. Algebraic and Transcendental equations.
   a) Solution of the given equations using Bisection Method – manual calculation.
   b) C++ program to find the solution using Bisection method and verification.

3. Curve Fitting – Linear Fit
   a) Principle of least square and fitting a straight line.
   b) C++ program to fit a straight line using the given data related with any physics experiment.

4. Curve Fitting – Non Linear Fit
   a) Principle of fitting a second degree polynomial using method of least square
   b) C++ program to fit a polynomial using the given data related with any physics experiment.

5. Interpolation
   a) Derive Lagrangian interpolation formula.
   b) C++ program to interpolate using the given data related with any physics experiment by Lagrangian Method

6. Solution of simultaneous equations -Gauss Elimination method.
   a) Procedure to solve Simultaneous equations using Gauss Elimination (GE) Method
   b) C++ program for solving unknown branch currents in Wheatstone's bridge using GE method.

7. Numerical solution of ordinary Differential Equations.

   a) Derivation of Exponential law of Radioactive decay.

   b) RK 4th order method of solving a given 1st order differential equation.

   c) C++ program using RK method to solve radioactive problem – Compare output with the Analytical result.

8. Area under the Curve - Numerical integration

   a) Derivation of Trapezoidal and Simpson's rule

   b) C++ programs for Trapezoidal and Simpson 1/3 rule

   c) Comparison of the program output with direct integration.

9. Random Number Generation and Montecarlo Method

   a) Generate and scale the random numbers for the desired range using the C++ library functions.

   b) Evaluate the given integral using Montecarlo method.

10. Matrix Multiplication

   a) Multiplication of two given matrices

   b) Rotation matrix definition.

   c) C++ program to rotate the given 2D- object about the origin using rotation matrix through the given angle.

11. Inverse of a Matrix

   a) Procedure to determine the Inverse of a Matrix using Gauss elimination Method.

   b) C++ Program to find the Inverse of a Matrix using Gauss Elimination Method.

12. Numerical Differentiation

   a) Numerical differentiation – related to any physical problem

   b) Derivation of Newton's law of cooling –equation

   c) C++ program to verify the Newton's law of cooling from the given experimental data.

Course Outcomes:

CO	On completion of this course, the students will be able to
CO1	Understand the strength of material using Young's modulus
CO2	Acquire knowledge of thermal behavior of the materials
CO3	Understand theoretical principles of magnetism through the experiments.
CO4	Acquire knowledge about arc spectrum and applications of laser
CO5	Improve the analytical and observation ability in Physics Experiments
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

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. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition.
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. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd
2. Advanced Practical Physics, S.P Singh, Pragati Prakasan
3. A course on experiment with He-Ne Laser, R.S. Sirohi, John Wiley & Sons (Asia) Pvt. ltd
4. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
5. Electronic Laboratory Primer a design approach, S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO 1	2	2	2	3	2	2	2	1
CO 2	2	2	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3
CO 4	3	2	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	2	2
Weightage	13	12	14	15	14	14	13	12
Weighted percentage of course contribution to POS	2.6	2.4	2.8	3	2.8	2.8	2.6	2.4

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	3	2
CO2	2	2	3	3	3
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3
Weightage	13	12	14	15	14
Weighted percentage of Course Contribution to PSOs	2.6	2.8	2.8	3	2.8

Strong-3 M-Medium-2 L-Low-1

Solar Energy Utilization

Title of the Course	Solar Energy Utilization						
Course Type	Skill Enhancement Course - III						
Year	II	Semester	IV	Credits	2	Course Code	24PSPH41
Instructional Hours per week		Lecture		Tutorial	Lab Practice	Total	
		2		2	--	4	

Learning Objectives	
LO1	To impart fundamental aspects of solar energy utilization.
LO2	To give adequate exposure to solar energy related industries
LO3	To harness entrepreneurship skills
LO4	To understand the different types of solar cells and channelizing them to the different sectors of society
LO5	To develop an industrialist mindset by utilizing renewable source of energy

Unit	Contents
I	**Heat Transfer & Radiation Analysis:** Introduction to sun and solar energy – Conduction, Convection and Radiation – Solar Radiation at the earth's surface – Earth radiation budget - Determination of solar time – Solar energy measuring methods and instruments- Analysis of Solar insolation.
II	**Solar Collectors:** Physical principles of conversion of solar radiation into heat flat plate collectors - General characteristics – Focusing collector systems – Thermal performance evaluation of optical loss.
III	**Solar Heaters:** Types of solar water heater - Solar heating system – Collectors and storage tanks – Solar ponds – Solar cooling systems – Design and cost estimation of a solar thermal system (Load analysis, system design, component list, price break down)
IV	**Solar Energy Conversion:** Photo Voltaic principles – Types of solar cells – Crystalline silicon/amorphous silicon and Thermo - electric conversion - process flow of silicon solar cells- different approaches on the process- texturization, diffusion, Antireflective coatings, metallization-Emerging solar cell technologies.
V	**Nanomaterials In Fuel Cell Applications:** Use of nanostructures and nanomaterial in fuel cell technology - high and low temperature fuel cells, cathode and anode reactions, fuel cell catalysts, electrolytes, ceramic catalysts. Use of Nano technology in hydrogen production and storage. **Industrial visit – data collection and analysis - presentation**

Course Outcomes:

Course Outcomes : CO	On completion of this course the student 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
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. Solar energy utilization -G.D. Rai –Khanna publishers – Delhi 1987.
2. Carbon Nano forms and Applications", Maheshwar Sharon, Madhuri Sharon, Mc Graw-Hill, 2010.
3. Solar Energy Engineering: Processes and Systems", Soteris A. Kalogirou Academic Press, London, 2009
4. Solar Energy – Fundamentals Design, Modelling and applications, Tiwari Narosa Publishing House, New Delhi, 2002
5. Solar Energy, Sukhatme S.P. 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.

6. Solar Domestic Water Heating "The Earthscan Expert Handbook for Planning, Design and Installation" published by Earthscan Ltd. ISBN: 978-1-84407-736-6
7. Solar Water and Pool Heating Manual: Design and Installation & Repair and Maintenance, FSEC-IN-24.

   Free download at: [PDF] Solar Water and Pool Heating Manual File Format: PDF/Adobe Acrobat - Quick View Pool Heating Manual. Design and Installation. &. Repair and Maintenance. Florida Solar Energy Center. Cocoa, Florida

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

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	3	3	2	2	2
CO2	2	3	2	2	3	3	2	3
CO3	2	3	2	2	2	2	3	3
CO4	2	2	2	3	2	3	2	3
CO5	2	2	3	2	3	3	3	3
Weightage	11	12	12	12	13	13	12	14
Weighted percentage of course contribution to POS	2.2	2.4	2.4	2.4	2.6	2.6	2.4	2.8

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	2	3	2	2	3
CO3	2	3	2	2	2
CO4	2	2	2	3	2
CO5	2	2	3	2	3
Weightage	11	12	12	12	13
Weighted percentage of Course Contribution to PSOs	2.2	2.4	2.4	2.4	2.6

Electromagnetic Theory

Title of the Course	**Electromagnetic Theory**						
Course Type	**Elective - VI**						
Year	**II**	**Semester**	**IV**	**Credits**	**4**	**Course Code**	**24PEPH41**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	4	**2**	**--**	**6**

Learning Objectives	After studying this topic, students should be able to
LO1	To acquire knowledge about boundary conditions between two media and the technique of method of separation of variables
LO2	To understand Biot – Savart's law and Ampere's circuital law
LO3	To comprehend the physical ideas contained in Maxwell's equations, Coulomb & Lorentz gauges, conservation laws
LO4	To assimilate the concepts of propagation, polarization, reflection and refraction of electromagnetic waves.
LO5	To grasp the concept of plasma as the fourth state of matter.

Unit	**Contents**
I	**Electromotive Force**: Faraday's law – Maxwell's equations – in free space and in linear isotropic media – conservation Energy and momentum in electrodynamics – Maxwell's stress tensor - Electromagnetic waves in nonconducting media – Electromagnetic waves in conductors – Reflection, refraction, interference, coherence, diffraction, polarization – Dispersion – Wave guides.
II	**Electrostatics:** Boundary value problems and Laplace equation – Boundary conditions and uniqueness theorem – Laplace equation in three dimension – Solution in Cartesian and spherical polar coordinates – Examples of solutions for boundary value problems. Polarization and displacement vectors - Boundary conditions - Dielectric sphere in a uniform field – Molecular polarizability and electrical susceptibility – Electrostatic energy in the presence of dielectric – Multipole expansion.
III	**Magneto Statics:** Biot-Savart's Law - Ampere's law - Magnetic vector potential and magnetic field of a localized current distribution - Magnetic moment, force and torque on a current distribution in an external field - Magneto static energy - Magnetic induction and magnetic field in macroscopic media - Boundary conditions - Uniformly magnetized sphere.
IV	**Maxwell Equations:** Faraday's laws of Induction - Maxwell's displacement current - Maxwell's equations - Vector and scalar potentials - Gauge invariance - Wave equation and plane wave solution- Coulomb and Lorentz gauges - Energy and momentum of the field - Poynting's theorem - Lorentz force - Conservation laws for a system of charges and electromagnetic fields.

V	**Wave Propagation:** Plane waves in non-conducting media - Linear and circular polarization, reflection and refraction at a plane interface - Waves in a conducting medium - Propagation of waves in a rectangular wave guide. Inhomogeneous wave equation and retarded potentials - Radiation from a localized source - Oscillating electric dipole

Course Outcomes: CO	**On completion of this 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
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. D. J.Griffiths , 2002, Introductionto Electrodynamics, 3rd Edition, Prentice-Hall of India, New Delhi.
2. J. R. Reitz, F. J. Milford and R. W. Christy, 1986, Foundations of Electromagnetic Theory, 3rd edition, Narosa Publishing House, New Delhi.
3. J. D. Jackson, 1975, Classical Electrodynamics, Wiley Eastern Ltd. New Delhi.
4. J. A. Bittencourt, 1988, Fundamentals of Plasma Physics, Pergamon Press, Oxford.
5. 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, Vol. 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

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	1	2	2	3	3
CO2	3	3	3	1	2	2	3	3
CO3	3	3	3	1	2	2	3	3
CO4	3	3	3	1	2	2	3	3
CO5	3	3	3	1	2	2	3	3
Weightage	15	15	15	5	10	10	15	15
Weighted percentage of course contribution to POS	3	3	3	1	2	2	3	3

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	2
CO2	3	3	3	1	2
CO3	3	3	3	1	2
CO4	3	3	3	1	2
CO5	3	3	3	1	2
Weightage	15	15	15	5	10
Weighted percentage of Course Contribution to PSOs	3	3	3	1	2

Quantum Field Theory

Title of the Course	**Quantum Field Theory**						
Paper Number	**Elective - VI**						
Year	**II**	**Semester**	**IV**	**Credits**	**4**	**Course Code**	**24PEPH42**

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	4	**2**	**-**	**6**

Learning Objectives	After studying this topic, students should be able to
LO1	To school the students about the analytical and numerical techniques of nonlinear dynamics.
LO2	To make the students understand the concepts of various coherent structures.
LO3	To train the students on bifurcations and onset of chaos.
LO4	To educate the students about the theory of chaos and its characterization.
LO5	To make the students aware of the applications of solitons, chaos and fractals.

Unit	**Contents**
I	**Symmetry Principles:** Relativistic kinematics, relativistic waves, Klein-Gordon (KG) equation as a relativistic wave equation, treatment of the KG equation as a classical wave equation: its Lagrangian and Hamiltonian, Noether's theorem and derivation of energy-momentum and angular momentum tensors as consequence of Poincaré symmetry, internal symmetry and the associated conserved current.
II	**Quantization Of Klein-Gordan Field:** Canonical quantization of the KG field, solution of KG theory in Schrödinger and Heisenberg pictures, expansion in terms of creation and annihilation operators, definition of the vacuum and N-particle eigenstates of the Hamiltonian, vacuum expectation values, propagators, spin and statistics of the KG quantum.
III	**Quantization Of Dirac Field:** Review of Dirac equation and its quantization, use of anti commutators, creation and destruction operators of particles and antiparticles, Dirac propagator, energy, momentum and angular momentum, spin and statistics of Dirac quanta.
IV	**Quantization Of Electromagnetic Fields:** Review of free Maxwell's equations, Lagrangian, gauge transformation and gauge fixing, Hamiltonian, quantization in terms of transverse delta functions, expansion in terms of creation operators, spin, statistics and p r o p a g a t o r of the photon.
V	**Perturbative Interaction At Tree Level:** Introduction to interacting quantum fields, Wick's Theorem, Feynman Diagram, Examples from quantum electrodynamics at the tree level: positron-electron and electron-electron scattering.

Course Outcomes:

Course Outcomes: CO	On completion of this course the student will be able to
CO1	Understand the interconnection of Quantum Mechanics and Special Relativity
CO2	Enable the students to understand the method of quantization to various field
CO3	Employ the creation and annihilation operators for quantization
CO4	Summarizes the interacting field, in quantum domain, and gives a discussion on how perturbation theory is used here.
CO5	Understand the concept of Feynman diagram
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. J. D. BjorkenandS. D. Drell,Relativistic Quantum FieldsDavid
2. An Introduction to Quantum Field Theory by M. Peskin and D. V. Schroeder
3. Quantum Field theory: From Operators to Path Integrals, 2nd edition by Kerson Huang
4. Quantum Field Theory by Mark Srednicki
5. Quantum Field Theory by Claude Itzykson and Jean Bernard Zuber.

Reference books:

1. V.B.Berestetskii,E.M.LifshitzandL.P.Pitaevskii,QuantumElectrodynamics
2. Introduction to the Theory of Quantized Fields by N. N. Bogoliubov and D. V. Shirkov (1959)
3. Quantum Field Theory by L. H. Ryder (1984)
4. Quantum Field Theory by L. S. Brown (1992)
5. Quantum Field Theory: A Modern Introduction by M. Kaku (1993)

Web resources:

1. https://homepages.dias.ie/ydri/QFTNOTES4v2.pdf
2. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/referencespapers.aspx?referenceid=2605249
3. https://archive.nptel.ac.in/courses/115/106/115106065/
4. http://www.nhn.ou.edu/~milton/p6433/p6433.html
5. https://plato.stanford.edu/entries/quantum-field-theory/

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	3	2	3	3
CO2	3	3	3	2	3	3	3	3
CO3	3	3	3	2	3	2	3	3
CO4	3	3	3	2	3	3	3	3
CO5	3	3	3	2	3	3	3	3
Weightage	15	15	15	10	15	13	15	15
Weighted percentage of course contribution to POS	3	3	3	2	3	2.6	3	3

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3
CO5	3	3	3	2	3
Weightage	15	15	15	10	15
Weighted percentage of Course Contribution to PSOs	3	3	3	2	3

Advanced Mathematical Physics

Title of the Course	**Advanced Mathematical Physics**						
Course Type	**Elective - VI**						
Year	**II**	**Semester**	**IV**	**Credits**	**4**	**Course Code**	**24PEPH43**
Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**			
	4	**2**	**--**	**6**			
Learning Objectives	To educate and involve students in the higher level of mathematics and mathematical methods relevant and applicable to Physics.						

Unit	Contents
I	**Discrete Groups:** Definition of a group, subgroup, class, Lagrange's theorem, invariant subgroup, Homomorphism and isomorphism between two groups. Representation of a group, unitary representations, reducible and irreducible representations Schur's lemmas, orthogonality theorem, character table, reduction of Kronecker product of representations, criterion for irreducibility of a representation.
II	**Continuous Groups:** Infinitesimal generators, Lie algebra; Rotation group, representations of the Lie algebra of the rotation group, representation of the rotation group, D- matrices and their basic properties. Addition of two angular momenta and C.G. coefficients, Wigner-Eckart theorem.
III	**Special Unitary Groups:** Definition of unitary, unimodular groups SU (2) and SU (3). Lie algebra of SU (2). Relation between SU (2) and rotation group. Lie algebra of SU (3) Gellmann's matrices. Cartan form of the SU (3). Lie algebra, roots and root diagram for SU(3). Weights and their properties, weight diagrams for the irreducible representations 3.3*-, 6, 6 8, 10 and 10 of SU (3). Direct product of two SU (3) representations, Young tableaux method of decomposition of products of IR's illustrations with the representations of dim<10. C.G.coefficients for 3 x 3* and 3 x 6 representations. SU (3) symmetry in elementary particle physics, quantum numbers of hadrons and SU (2) and SU(3) classification of hadrons.
IV	**Tensors:** Cartesian vectors and tensors illustration with moment of inertia, conductivity, dielectric tensors. Four vector in special relativity, vectors and tensors under Lorentz transformations, Illustration from physics. Vectors and tensors under general co-ordinate transformations, contravariant and covariant vectors and tensors, mixed tensors; tensor algebra, addition, subtraction, direct product of tensors, quotient theorem, symmetric and antisymmetric tensors.
V	**Tensor Calculus:** Parallel transport, covariant derivative, affine connection. Metric tensor. Expression for Christoffel symbols in terms of and its derivatives (assuming D g = 0. Curvature tensor, Ricci tensor and Einstein tensor. Bianchi identities, Schwarzschild solution to the Einstein equation G=0.

Course Outcomes:

Course Outcomes: CO	On completion of this course the student 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
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Texts:

1. A.W.Joshi, Group Theory for Physicists
2. D.B.Lichtenberg, Unitary Symmetry and Elementary Particles
3. E.Butkov, Mathematical Physics
4. J.V.Narlikar, General Relativity & Cosmology
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. https://vdoc.pub/documents/unitary-symmetry-and-elementary-particlesc4qsfejthkc0
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 mathematical-physics
5. https://www.springer.com/journal/11232

Mapping with Programme Outcomes and Programme Specific Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	1	2	1	2
CO2	3	3	2	1	1	1	1	2
CO3	3	3	2	1	2	2	1	2
CO4	3	3	2	2	1	2	1	2
CO5	3	3	2	2	2	1	1	2
Weightage	15	15	10	7	7	8	5	10
Weighted percentage of course contribution to POS	3	3	2	1.4	1.4	1.6	1	2

S-Strong-3 M-Medium-2 L-Low-1

CO /PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	1	1
CO2	3	3	2	1	1
CO3	3	3	2	1	2
CO4	3	3	2	2	1
CO5	3	3	2	2	2
Weightage	15	15	10	7	7
Weighted percentage of Course Contribution to PSOs	3	3	2	1.4	1.4

List - I - Academic Extension Activity

1. **Entrepreneurship and Innovation Workshop Series**
   Empowering students to develop entrepreneurial skills and explore opportunities for commercializing physics-related technologies or starting their ventures.

2. **Computational Physics Hackathon**
   Organizing hackathons or coding competitions focused on solving physics problems using computational techniques, fostering collaboration and innovation among students**Science Education Outreach Program**
   Involving students in educational outreach activities, such as designing and delivering physics workshops for schools or mentoring undergraduate students in projects.

3. **Physics in Your Pocket**
   An interactive workshop series exploring the physics concepts and experiments that can be conducted using sensors available in mobile phones, covering topics such as motion, sound, light & magnetism and monitoring air quality, temperature, humidity, and pollution levels in various locations (student residence)

4. **Conduct Virtual Experiments and Prepare Reports**
   a) Conduct the diffraction at a slit experiment virtually using the following link https://www.walter-fendt.de/html5/phen/singleslit_en.htm
      i) Measure the angular spread (Θ) for different slit widths (Δx) for given wavelength of the incident photon. ii). Determine the momentum of the incident photon using, p=h/λ
      iii) . Create a line of best fit through the points in the plot 1 Δpx against $\Delta x$and find its slope. How this exercise is related to Heisenberg Uncertainty principle Make a report of the observations
   b) Virtual lab - Photoelectric effect using Value@Amritha: link https://vlab.amrita.edu/?sub=1&brch=195&sim=840&cnt=1
      i) Determine the minimum frequency required to have Photoelectric effect for an EM radiation, when incident on a zinc metal surface. ii) . Determine the target material if the threshold frequency of EM radiation is$5.5x10^{15}$ Hz in a particular photoelectric experimental set up.
      iii) Determine the maximum kinetic energy of photo-electrons emitted from a Zinc metal surface,
      if the incident frequency is $3x10^{15}$Hz. Make a report of the calculations
   c) Visualization of wave packets using Physlet@Quantum Physics: https://www.compadre.org/PQP/quantum-need/prob5_11.cfm
      Six different classical wave packets are shown in the animations. Which of the wave packets have a phase velocity that is: greater than / less than / equal to the group velocity? Make a report of the observations.

5. **Construction of physics Models**
6. **Science Club Activities**
   (Report for the Extension activity shall be submitted by the students individually)

Field Visit/WORK

Fieldwork, as a derived concept, is the practical work carried out by students outside the classroom or laboratory in order to acquire hands-on experience, handle data, make observations, and interact with areas that are actual, involving the subject of their studies or professional practices. Practical field work includes having an interaction with nature, field sites, fancy tools, instruments, and local communities for discussion of the specific topics and studies to collect, investigate and analyze or for the utilization in disciplines of natural sciences, social sciences, humanities, engineering and other professional fields.

Following are some of the fieldwork activities a student or group of students may undertake.

(Not only restricted to the following activities)

Atmospheric Physics Measurements: Perform atmospheric physics measurements, such as temperature, humidity, and pressure, using weather stations or handheld instruments.

Study atmospheric phenomena, weather patterns, and climate change indicators.

Water Quality Analysis: Collect water samples from lakes, rivers, or oceans to analyze water quality parameters, such as pH, salinity, and dissolved oxygen. Investigate water pollution sources, ecological impacts, and aquatic ecosystems.

Wind Energy Measurements: Conduct wind speed and direction measurements using anemometers and wind vanes at potential wind farm sites.

Study wind energy potential, turbine design, and wind farm optimization.

Thermal Power Plant Tour and Operation Overview: Organize a guided tour of a thermal power station to study the overall operation, energy generation processes, and power plant components, such as boilers, turbines, and generators. Learn about thermal power generation principles, steam cycles, and energy conversion efficiency.

Nuclear Power Plant Tour: Organize a guided tour of a nuclear power plant to study nuclear reactor design, operation, and safety measures.

Learn about nuclear fuel cycles, reactor control systems, and radiation monitoring.

Observational Astronomy: Organize a field trip to an observatory or a dark sky site for astronomical observations using telescopes. Study celestial objects, such as planets and stars.

Solar Observations: Conduct solar observations using solar telescopes or solar filters or collect data from solar observatories to study sunspots, solar flares, and solar prominences. Analyze solar activity and its impact on space weather.

Space Observatory Field Trip: Visit space observatories, astronomical research facilities, or satellite ground stations to study space exploration missions, astronomical observations, and satellite communications. Explore telescope technologies, observational techniques, and data acquisition systems.

Rocket Launch and Space Mission Observation: Attend rocket launch events, space mission launches, or spacecraft test flights to observe space launch operations, rocket propulsion systems, and aerospace technologies. Explore launch vehicle designs, mission profiles, and space exploration advancements.

Geomagnetic Field Measurements: Conduct geomagnetic field measurements using magnetometers at different locations to study Earth's magnetic field variations. Investigate geomagnetic storms, magnetic anomalies, and their effects on Earth's environment.

Data Science and Machine Learning Workshop: Attend workshops or training sessions on data science, machine learning, and artificial intelligence applications in physics research. Explore data analytics, pattern recognition, and predictive modeling techniques.

(Report for the Internship/ Field visit/ Industrial Visit/ Research Knowledge Updating Activity shall be submitted by the students individually)

Project Work

Rules and Regulations for PG Physics Project

Individual Project	Each candidate must undertake an individual project. Group projects are not permitted
Project Types	Projects must be based on one or more of the following areas: • Theoretical Physics • Experimental Physics • Computational Physics • Scientific Data Analysis
Prohibited Projects	• Readymade projects are not recommended • Electronic construction projects, IOT projects are not allowed unless they are the original idea of the student and approved by the project supervisor.
Project Report	• Students must adhere to the template provided for the preparation of their project reports. • The report should include an abstract, introduction, literature review, methodology, results, discussion, conclusion, and references.
Originality and Plagiarism	• Projects must be original work by the student. • Plagiarism in any form is strictly prohibited and will result in disqualification.
Supervision	• Each project must be supervised by a faculty member. • Regular updates and consultations with the supervisor are mandatory
Safety and Ethics	• Students conducting experimental projects must follow all laboratory safety protocols. • Ethical guidelines in research must be strictly followed
Evaluation	• Projects will be evaluated by the external examiners based on originality, methodology, analysis, and adherence to the provided template. • Both a written report and an oral presentation may be required as part of the evaluation process.
Students are encouraged to consult their supervisors and the department for any clarifications regarding these rules and regulations	
Internal : 40 Marks and External : 60 Marks	

Format for Preparation of Project Report

Students are required to submit a Project report at the end of Semester - IV and also required to make presentation of the project work during Viva- voce Examination. Each student should submit two copies of the project report with a minimum of 50 pages not exceeding 75 pages to the Department on or before the date notified for the same.

The sequence in which the project report should be arranged and bound should be as Follows

1	Cover Page and Title Page
2	Certificate
3	Declaration
4	Acknowledgement (not exceeding one page)
5	Abstract
6	Contents
7	List of Figures / Exhibits / Charts/ Circuit Diagrams
8	List of tables
9	Symbols and notations
10	Chapters
11	Result and Discussion
12	Conclusion
13	References
14	Xerox Copies of Publications/Certificates of Seminar, Conference Participation if any

Running matter - Times New Roman, Font size 12, with 1.5 line spacing

Blue Print – End Semester Examinations Semester – I to IV

Class: P.G. **Time: 3 Hours** **Max. Marks: 75**

Section A **(10 x 1 = 10)**

Answer all questions.

Choose the correct answer.
(With four options)

	Unit I	Unit II	Unit III	Unit IV	Unit V
Question Nos.	1 & 2	3 & 4	5 & 6	7 & 8	9 & 10

Section B **(5 x 5 = 25)**

Answer all questions choosing either (a) or (b).

Answer should not exceed 250 words

	Unit I	Unit II	Unit III	Unit IV	Unit V
Question Nos.	11 (a) & 11 (b)	12 (a) & 12 (b)	13 (a) & 13 (b)	14 (a) & 14 (b)	15 (a) & 15 (b)

Section C **(5 x 8 = 40)**

Answer all questions choosing either (a) or (b).

Answer should not exceed 500 words

	Unit I	Unit II	Unit III	Unit IV	Unit V
Question Nos.	16 (a) & 16 (b)	17 (a) & 17 (b)	18 (a) & 18 (b)	19 (a) & 19 (b)	20 (a) & 20 (b)