PERIYAR UNIVERSITY

SALEM – 636 011

M.Sc., (PHYSICS)

[Choice Based Credit System (CBCS)]

REGULATIONS AND SYLLABUS

(Effective from the academic year 2023-2024 and thereafter)

CONTENTS

1. Preamble

Department of Physics was established in the year of 2004. From the very inception, the department has been conducting M.Sc., M.Phil. and Ph.D. degree programmes in Physics. The main objectives of the department are to provide high quality teaching and research. This creates knowledge and skill based society to challenge the current and future scientific and technology developments. The designed syllabi facilitate the stakeholders to perceive the wide spectrum of knowledge in physics and this will make them to pursue research in national laboratories in India and abroad and to hold key positions in scientific and academic arena at various capacities. This syllabi covers to teach several important core areas of physics and some elective and interdisciplinary subject areas, which allows the stakeholders to broaden their knowledge beyond pure physics. The subjects being taught in the department includes, Classical Mechanics, Mathematical Physics, Quantum Mechanics and Statistical Mechanics are the mathematical based analytical subjects of physics and this forms a good platform for learning other subjects in physics as well as physical and chemical sciences. Apart from that the Electronic subjects, Solid state physics, Electromagnetic theory, Spectroscopy, Modern Optics and Computer programming and simulation are some of the core and elective subjects intact in the curriculum. Experiments for the advanced level Electronics and General physics practical have designed to enrich the stakeholders to attain experimental understanding and computer simulations.

Creation of new knowledge by doing cutting edge research is the another goal of the department. To accomplish the same, the department involved research in the areas of structural investigation of crystalline materials by X-ray Crystallography, Molecular dynamics simulation and Quantum chemical calculations, Synthesis of new biomaterials, Energy materials, Fabrication of new solar cells, Supercapacitors and Molecular modelling. The research programmes being conducted in the Department met several challenges disseminate new materials, designing novel materials and molecules of medicinal importance.

2. Learning and Teaching Activities

1.1 Topic wise Delivery Method

Hour Count	Topic	Unit	Mode of Delivery

1.2 **Work Load**

The information below is provided as a guide to assist students in engaging appropriatelywith the course requirements.

Activity	Quantity	Workload Periods
Lectures	60	60
Tutorials	15	15
Assignments	5	5
Cycle Test or similar	2	4
Model Test or similar	1	3
University Exam	1	3
Total		**90 periods**

3. Tutorial Activities

Tutorial Count	Topic

4. Laboratory Activities

S. No.	Semester	Course
1.	I	Practical -I
2.	II	Practical -II
3.	III	Practical -II

5. Field Study Activities

Industrial Visit during third or fourth Semester

6. Assessment Activities

6.1 Assessment Principles:

Assessment for this course is based on the following principles:

1. Assessment must encourage and reinforce learning.
2. Assessment must measure achievement of the stated learning objectives.
3. Assessment must enable robust and fair judgments about student performance.
4. Assessment practice must be fair and equitable to students and give them the opportunity to demonstrate what they learned.
5. Assessment must maintain academic standards.

6.2 Assessment Details:

Assessment Item	Distributed Due Date	Weightage	Cumulative Weightage
Assignment 1	3rd week	1%	1%
Assignment 2	6th Week	1%	2%
Cycle Test – I	7th Week	5%	7%
Assignment 3	8th Week	1%	8%
Assignment 4	11th Week	1%	9%
Cycle Test – II	12th Week	5%	14%
Assignment 5	14th Week	1%	15%
Model Exam	15th Week	5%	20%
Seminar	-	5%	25%
University Exam	17th Week	75%	100%

7. Teaching Methodologies

7.1 Traditional Teaching method like Chalk and Board, Virtual Class room, LCD projector, Smart Class, Video Conference, Guest Lectures.

7.2 Asking students to formulate a problem from a topic covered in a week's time Assignment, Class Test, Slip test

7.3 Asking students to use state-of-the-art technologies/software to solve problems Applications, Use of FORTRAN, ORIGIN software

7.4 Introducing students to applications before teaching the theory

7.5 Training students to engage in self-study without relying on faculty (for example – library and internet search, manual and handbook usage, etc.)

7.5.1. Library, Net Surfing, Manuals, NPTEL Course Materials published in the website

7.5.2. Other university websites.

8. Faculty Course File Structure

a. Academic Schedule

b. Students Name List

c. Time Table

d. Syllabus

e. Lesson Plan

f. Staff Workload

g. Course Design (content, Course Outcomes (COs), Delivery method, mapping of Cos with Programme Outcomes (POs), Assessment Pattern in terms of Revised Bloom's Taxonomy)

h. Sample CO Assessment Tools.

i. Faculty Course Assessment Report (FCAR)

j. Course Evaluation Sheet

k. Teaching Materials (PPT, OHP etc.)

l. Lecture Notes

m. Home Assignment Questions

n. Tutorial Sheets

o. Remedial Class Record, if any.

p. Projects related to the Course

q. Laboratory Experiments related to the Courses

r. Internal Question Paper

s. External Question Paper

t. Sample Home Assignment Answer Sheets

u. Three best, three middle level and three average Answer sheets

v. Result Analysis (CO wise and whole class)

w. Question Bank for Higher studies Preparation (GATE/Placement)

x. List of mentees and their academic achievements

9. Template for PG Programme in Physics

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VIII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	4	3.5 Discipline Centric Elective - V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I	2	4	3.6 NME II	2	3	4.6 Extension Activity	1	
						3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**22**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -91											

10. Course Structure

FIRST SEMESTER

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1C01	Paper 1- Mathematical Physics	7	6	1	0	5
23UPPHY1C02	Paper 2 - Classical Mechanics and Relativity	7	6	1	0	5
23UPPHY1C03	Paper 3 – Practical I – General Physics	6	0	0	6	4
23UPPHY1E--	Discipline Centric Elective – I (Choose any one from the list - I)	5	4	1	0	3
23UPPHY1E--	Generic Elective – II (Choose any one from the list - I)	5	4	1	0	3

SECOND SEMESTER

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1C04	Paper 4 – Quantum Mechanics	6	5	1	0	5
23UPPHY1C05	Paper 5 - Numerical Methods and Computer Programming	6	5	1	0	5
23UPPHY1C06	Paper 6 – Practical – II - Electronics, Microprocessor and Microcontroller	6	0	0	6	4
23UPPHY1E--	Discipline Centric Elective – III (Choose any one from the list - II)	4	3	1	0	3
23UPPHY1E--	Generic Elective – IV (Choose any one from the list - I or II)	4	3	1	0	3
23UPPGC1H01	Human Rights	1	1	0	0	1
-	NME – I (Online Course- SWAYAM/NPTEL)	0	0	0	0	2

**** Internship will be carried out during the summer vacation of the first year and marks will be included in the Third Semester Marks Statement.**

THIRD SEMESTER

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1C07	Paper 7– Electromagnetic Theory	6	5	1	0	5
23UPPHY1C08	Paper 8 - Spectroscopy	6	5	1	0	5
23UPPHY1C09	Paper 9 – Statistical Mechanics	6	5	1	0	5
23UPPHY1C10	Paper 10 – Practical - III - Computational Programming and Simulation	6	0	0	6	4
23UPPHY1E--	Discipline Centric Elective – III (Choose any one from the list - I or II)	3	3	0	0	3
23UPPHY1N--	NME – II	3	3	0	0	2
23UPPHY1I01	Internship / Industrial Activity **	0	0	0	0	2

**** Internship will be carried out during the summer vacation of the first year and marks will be included in the Third Semester Marks Statement.**

FOURTH SEMESTER

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1C11	Paper 11– Nuclear and Particle Physics	6	5	1	0	5
23UPPHY1C12	Paper 12 - Condensed Matter Physics	6	5	1	0	5
23UPPHY1C13	Project with Viva-Voce	10	0	0	10	7
23UPPHY1E--	Elective - VI Choose any one from the list - III (Industry / Entrepreneurship) 20% Theory 80% Practical	4	1	0	3	3
23UPPHY1E--	Skill Enhancement course / Professional Competency Skill (Choose any one from the list -IV)	4	3	1	0	2
23UPPHY1X01	Extension Activity	-	1	0	0	1

ELECTIVE PAPERS

LIST – I

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1E01	Linear and Digital ICs and Applications	5	4	1	0	3
23UPPHY1E02	Physics of Nano Science and Technology	5	4	1	0	3
23UPPHY1E03	Energy Physics	5	4	1	0	3
23UPPHY1E04	Crystal Growth and Thin films	5	4	1	0	3
23UPPHY1E05	Analysis of Crystal Structures	5	4	1	0	3
23UPPHY1E06	Materials Science	5	4	1	0	3
23UPPHY1E07	Digital Communication	5	4	1	0	3
23UPPHY1E08	Communication Electronics	5	4	1	0	3

LIST - II

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1E09	Microprocessor 8086 and Microcontroller 8051	4	3	1	0	3
23UPPHY1E10	Plasma Physics	4	3	1	0	3
23UPPHY1E11	Bio Physics	4	3	1	0	3
23UPPHY1E12	Non-linear Dynamics	4	3	1	0	3
23UPPHY1E13	Quantum Field Theory	4	3	1	0	3
23UPPHY1E14	General Relativity and Cosmology	4	3	1	0	3
23UPPHY1E15	Advanced Optics	4	3	1	0	3
23UPPHY1E16	Advanced Mathematical Physics	4	3	1	0	3

LIST - III

INDUSTRY ORIENTED ELECTIVE (IOE)

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1E17	Advanced Spectroscopy	4	1	0	3	3
23UPPHY1E18	Characterization of Materials	4	1	0	3	3
23UPPHY1E19	Medical Physics	4	1	0	3	3
23UPPHY1E20	Solid Waste Management	4	1	0	3	3
23UPPHY1E21	Sewage and Waste Water Treatment and Reuse	4	1	0	3	3
23UPPHY1E22	Solar Energy Utilization	4	1	0	3	3

(**Note:** Institutions can also frame such IOE courses more suitable for their locality.)

LIST - IV

SKILL ENHANCEMENT COURSES

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1E23	Design and Installation of Solar Photovoltaic System	4	3	1	0	2
23UPPHY1E24	Analytical Instrumental Methods	4	3	1	0	2
23UPPHY1E25	Industrial Semiconductor Devices	4	3	1	0	2
23UPPHY1E26	Silicon Wafer Technology for Photonics	4	3	1	0	2
23UPPHY1E27	Biomaterials	4	3	1	0	2
23UPPHY1E28	Powder x-ray diffraction and analysis	4	3	1	0	2

LIST - V

NON MAJOR ELECTIVE COURSES

COURSE CODE	NAME OF THE COURSE	INST. HRS	L	T	P	CREDIT
23UPPHY1N01	Electronics in Daily Life	3	2	1	0	2
23UPPHY1N02	Geophysics	3	2	1	0	2
23UPPHY1N03	Molecular Biophysics	3	2	1	0	2
23UPPHY1N04	Non-Linear Optics	3	2	1	0	2
23UPPHY1N05	Laser Physics and Applications	3	2	1	0	2

Core Courses	**-64 Credits**
Elective Courses	**-20 Credits**
Non Major Electives	**- 4 Credits**
Extension Activity	**- 1 Credit**
Internship	**- 2 Credits**
Human Rights	**- 1 Credit**
Total Credits	**-92**

VALUE ADDED COURSES (Extra)

Sem.	Course Code	Name of the course	Credits	No. of Hours	Marks
III	23UPPHY1V01	Optical System Analysis and Design	2	30	100
	23UPPHY1V02	Solar Physics	2	30	100
	23UPPHY1V03	Radiation Physics	2	30	100

11. Testing Pattern

(Internal 25 + External 75)

11.1 Internal

Theory Course: For theory courses there shall be three tests conducted by the faculty concerned and the average of the best two can be taken as the Continuous Internal Assessment (CIA) for a maximum of 25 marks. The duration of each test shall be one and a half hour. Internal mark distribution for theory paper is as given below.

Theory : Cycle Test : 15

Assignment : 5

Seminar : 5

Total : 25

Practical Courses: Internal mark distribution for practical course is as below.

Observation : 10

Cycle Test : 10

Record : 5

Total : 25

11.2 Written examination: Theory paper (Bloom's Taxonomy based)

Theory Paper - Question Paper Model

Intended Learning Skills	**Maximum 75 Marks** **Passing Minimum: 50%** **Duration : Three Hours**
Memory Recall / Example/Counter Example / Knowledge aboutthe Concepts/ Understanding (K1 & K2)	Part –A (20 X 1 = 20 Marks) Answer ALL questions Each Question carries 1 Mark
	FOUR questions from each UNIT
	Question 1 to Question 20
Descriptions/ Application(problems)	Part – B (5 X 3 = 15 Marks) Answer any THREE questions Each questions carries 5 Marks

(K3 & K4)	There shall be FIVE questions covering all the fiveunits
	Question 20 to Question 25
Analysis /Synthesis / Evaluation (K5 & K6)	Part-C (5 X 8 = 40 Marks) Answer ALL questions Each question carries 8 Marks
	Either-or Type Both parts of each question from the same UNIT
	Question 26 (a) or 26 (b) to Question 30 (a) or 30 (b)

12. Programme Educational Objectives (PEO), Programme Specific Objectives (PSO) and Programme Outcomes (PO)

PEO1: The main aim of the M.Sc (Physics) programme is to have enriched syllabus prepared based on the recent scientific developments in physics and its interdisciplinary areas and to meet out the requirements of today's academic, research and industry requirements.

PEO2: To teach core subjects of physics to students to acquire knowledge and to have in-depth understanding about the laws of physics, concepts, principles and solve analytical problems.

PEO3: To teach practical courses that is to attain knowledge in advanced physics experiments by independently perform the same, and to clarify the theory learned in core subjects. To introduce skill based courses training the students to handle advanced equipment and computational knowledge.

PEO4: To provide and teach certain popular courses which are not in conventional core courses considered as elective subjects essential for students to take up their research after completion of the postgraduate course.

PEO5: To provide training to students to perform research in physics and interdisciplinary areas, the course has a room that student to carry out research projects and enable the students to obtain research carrier in R & D labs and industry.

Programme Specific Objectives (PSOs)

PSO1: To educate the students how to use the methods of mathematical physics in broad spectrum of physics, particularly in classical and quantum mechanics.

PSO2: To teach quantum mechanics to students to understand the microscopic phenomena of all branches of physics. And to solve various problems using different exact and approximation methods of quantum mechanics, which helps students to resolve problems in quantum statistics, spectroscopy of molecules, and nuclear and particle physics.

PSO3: To teach the students to be specialized in condensed matter physics as it provides the fundamental science of solids and liquids, and it is the foundations of most technologies; in-depth understanding of this subject allows the students to do research in both basic sciences and technological applications.

PSO4: To develop the skill on programming and computational simulation techniques to resolve various numerical problems in physics, chemistry and biology.

PSO5: To develop the skill and ability of the students to design, conduct, observe, analyzes and report practical experiments. And to provide research training, particularly in X-ray crystallography, quantum chemical calculations, molecular dynamics simulation, nanoscience, biophysics, biomaterials, synthesis of novel materials, fabrication of solar cells, energy materials.

Programme Outcomes (Pos)

After completion of the M.Sc., (Physics) programme the students able to

PO1: Apply the knowledge of mathematical physics to understand the complex problems in quantum physics, spectroscopy, condensed matter physics, nuclear and particle physics.

PO2: Critically analyze the complex problems in different core subject areas of physics and find the solution.

PO3: Apply the theoretical knowledge and creative ideas allow independently design new electronic devices and establish new research oriented microprocessor and microcontroller experiments.

PO4: Solve the scientific problems via computer simulation and programme writing skills also gained.

PO5: Apply the concepts, acquired research training, experimental/computational experience to work in concerned research areas.

13. Syllabus

CORE COURSES

PAPER-01 - MATHEMATICAL PHYSICS	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C01	**MATHEMATICAL PHYSICS**	Core	6	1	0	5	7	75

Learning Objectives
➢ To develop knowledge in mathematical physics and its applications. ➢ To develop expertise in mathematical techniques required in physics. ➢ To enhance problem solving skills. ➢ To enable students to formulate, interpret and draw inferences from mathematical solutions. ➢ To increase the knowledge on integral transforms.

UNITS	Course Details
UNIT I: LINEAR VECTOR SPACE & TENSOR ANALYSIS	**Linear Vector Space**: Basic concepts - Definitions- examples of vector space - Linear independence - Scalar product- orthonormal vector - Orthogonality - Gram-Schmidt orthogonalization procedure - Schwarz inequality - linear operators - orthogonal transformations and rotation. **Tensor Analysis:** Definition of tensor- contravariant, covariant and mixed tensors – Addition and subtraction of tensors – Isotropic tensor- Summation convention- Symmetry and anti-symmetry tensor - Contraction and direct product – Quotient law of Tensor.
UNIT II: COMPLEX ANALYSIS	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- poles – Residue theorem and its application.
UNIT III: 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
UNIT IV: FOURIER TRANSFORMS & LAPLACE TRANSFORMS	Introduction to Fourier transform and its derivatives - Cosine and sine transforms - Convolution theorem. Application: Diffusion equation: Flow of heat in an infinite and in a semi - infinite medium - Wave equation: Vibration of an infinite string and of a semi - infinite string. Laplace transform and its inverse - Transforms of derivatives and integrals - Differentiation and integration of transforms - Dirac delta functions - Application - Laplace equation: Potential problem in a semi - infinite strip.

UNIT V: DIFFERENTIAL EQUATIONS	Second order differential equations- 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 -Sturm-Liouville's type equation in one dimension & their Green's function.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert lectures, Online seminars - webinars on industrial interactions/visits, competitive examinations, employable and communication skill enhancement, social accountability and patriotism
TEXT BOOKS	1. Mathematical Physics - H. K. Dass and Rama Verma, S. Chand Publications, 8th Edition, 2019. 2. Mathematical Physics with Classical Mechanics, Satya Prakash, Sultans Chand & Sons Publications, 7th Edition, 2021. 3. Mathematical Methods for Physicists – A Comprehensive Guide, George Arfken and Hans J Weber, Academic press, 7th Edition, 2012. 4. Mathematical Physics, P.K. Chattopadhyay, New Age International Private Limited, 3rd Edition, 2022. 5. Mathematical Physics, B. D. Gupta, S Chand And Company Ltd, 4th Edition, 2022.
REFERENCE BOOKS	1. Advanced Engineering Mathematics, E. Kreyszig, Wiley Eastern, 10th Edition, 2011. 2. Advanced Engineering Mathematics, D. G. Zill and M. R. Cullen, Jones & Bartlett Learning, 6th Edition, 2018. 3. Linear Algebra, S. Lipschutz, Schaum's Series, McGraw - Hill, 4th Edition, 2009. 4. Finite Dimensional Vector Spaces, P. R. Halmos, Benediction Classics, latest Edition,2023. 5. Advanced Engineering Mathematics, C. R. Wylie and L. C. Barrett, McGraw-Hill, 6th Edition, 1995.
WEB SOURCES	1. www.khanacademy.org 2. https://youtu.be/LZnRlOA1_2I 3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath 4. https://www.youtube.com/watch?v=_2jymuM7OUU&list=PLhkiT_RYTEU27vS_SlED56gNjVJGO2qaZ 5. https://archive.nptel.ac.in/courses/115/106/115106086/

COURSE OUTCOMES:

At the end of the course the student will be to:

CO1	Understand use of bracket vector notation and explain the meaning of complete orthonormal set of basis vectors, and transformations and be able to apply them	**K1 K2 K3 K4 K5 K6**
CO2	Understand analytic functions, do complex integration, by applying Cauchy Integral Formula. Able to compute many real integrals and infinite sums via complex integration.	
CO3	Analyze characteristics of matrices and its different types, and the process of diagonalization.	
CO4	Solve equations using Laplace transform and analyze the Fourier transformations of different function, grasp how these transformations can speed up analysis and correlate their importance in technology	
CO5	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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	3	3
CO2	2	3	3	3	2
CO3	3	3	3	2	3
CO4	3	3	3	2	3
CO5	3	2	3	2	3

PAPER-02 - CLASSICAL MECHANICS AND RELATIVITY	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C02	**CLASSICAL MECHANICS AND RELATIVITY**	Core	6	1	0	5	7	75

Learning Objectives
➢ To understand fundamentals of classical mechanics. ➢ To understand Lagrangian formulation of mechanics and apply it to solve equation of motion. ➢ To understand Hamiltonian formulation of mechanics and apply it to solve equation of motion. ➢ To discuss the theory of small oscillations of a system and Grasp Hamilton-Jacobi equations ➢ To learn the relativistic formulation of mechanics of a system and solve the central force field problems

UNITS	Course Details
UNIT I: PRINCIPLES OF CLASSICAL MECHANICS	Mechanics of a single 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.
UNIT II: LAGRANGIAN FORMULATION	D'Alembert's principle – Lagrangian equations of motion for conservative systems – applications: (i) simple pendulum (ii) Atwood's machine (iii) projectile motion.
UNIT III: HAMILTONIAN FORMULATION	Phase space – cyclic coordinates – Hamiltonian function – variational principle- Hamilton's equations from variational principle - Hamilton's canonical equations of motion – applications: (i) simple pendulum (ii) one dimensional simple harmonic oscillator (iii) motion of particle in a central force field.
UNIT IV: HAMILTON –JACOBI THEORY AND SMALL OSCILLATIONS	Hamilton-Jacobi equation for Hamilton's principle function-Example: Harmonic oscillator problem-Formulation of the problem – Transformation to normal coordinates – Frequencies of normal modes – Linear triatomic molecule. -Action-angle variable-application to Kepler problem in action angle variables
UNIT V: CENTRAL FORCE PROBLEM AND RELATIVITY	Reduction to the equivalent one body problem - Centre of mass-Kepler problem: Inverse-Square law of force- – Lorentz transformation equations – length contraction and time dilation – relativistic addition of velocities – Einstein's mass-energy relation– four vectors – position, velocity, momentum, acceleration and force in four vector notation and their transformations

Extended Professional Component	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Classical Mechanics, H. Goldstein, Pearson Edu., 3rd Edition, 2022 2. Classical Mechanics, J. C. Upadhyaya, Himalaya Publishing Co., New Delhi, 2019 3. Introduction to Special Theory of Relativity, R. Resnick, Wiley Eastern, New Delhi, 2007 4. Introduction to Classical Mechanics, R. G. Takwala and P.S. Puranik, Tata McGraw Hill, New Delhi, 1980 5. Classical Mechanics, N. C. Rana and P.S. Joag, Tata McGraw Hill, 2001 6. Classical Mechanics, B.D. Gupta and Satya Prakash, Keder Nath Publishers, Meerut, Revised Edition, 2015
REFERENCE BOOKS	1. Mechanics, K. R. Symon, Addison Wesley, London, 1971 2. Classical Mechanics, S. N. Biswas, Books & Allied, Kolkata, 1999 3. Classical Mechanics, Gupta and Kumar, Kedar Nath, 2020 4. Classical Mechanics, T.W.B. Kibble, ELBS, 2004 5. Classical Dynamics, Greenwood, PHI, New Delhi, 2023
WEB SOURCES	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

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the fundamentals of classical mechanics.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Apply the principles of Lagrangian and Hamiltonian mechanics to solve the equations of motion of physical systems.	
CO3	Apply the principles of Lagrangian, Hamiltonian and Hamilton-Jacobi mechanics to solve the equations of motion of physical systems.	
CO4	Analyze the small oscillations in systems and determine their normal modes of oscillations.	
CO5	Understand and apply the principles of relativistic kinematics and central force to the mechanical systems.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; **K6 - Create**		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER – 03 - PRACTICAL - I - GENERAL PHYSICS	I YEAR – I SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C03	**PRACTICAL - I - GENERAL PHYSICS**	Core	0	0	6	4	6	75

Learning Objectives

- To understand the concept of mechanical behavior of materials and calculation of same using appropriate equations.
- To calculate the thermodynamic quantities and physical properties of materials.
- To analyze the optical and electrical properties of materials.

(Any Twelve Experiments)

1. Determination of Young's modulus and Poisson's ratio by Hyperbolic fringes - Cornu's Method
2. Determination of Viscosity of the given liquid – Meyer's disc
3. Measurement of Coefficient of linear expansion- Air wedge Method
4. B-H loop using Anchor ring.
5. Determination of Thickness of the enamel coating on a wire by diffraction
6. Determination of Rydberg's Constant - Hydrogen Spectrum
7. FP Etalon
8. Determination of Thickness of air film. - Solar spectrum – Hartmann's formula. Edser and Butler fringes.
9. Measurement of Band gap energy- Thermistor
10. Determination of Planck Constant – LED Method
11. Determination of Specific charge of an electron – Thomson's method.
12. Determination of Compressibility of a liquid using Ultrasonics
13. Determination of Wavelength, Separation of wavelengths - Michelson Interferometer
14. GM counter – Characteristics, inverse square law and absorption coefficient.
15. Measurement of Conductivity - Four probe method.
16. Arc spectrum – Iron.
17. Molecular spectra – AlO band.
18. Measurement of wavelength of Diode Laser / He – Ne Laser using Diffraction grating.
19. Determination of Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
20. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
21. Measurements of Standing wave and standing wave co-efficient, Law of Inverse square, Receiver end transmitter behavior, Radiation Pattern - Microwave test bench
22. UV-Visible spectroscopy – Verification of Beer-Lambert's law and identification of wavelength maxima – Extinction coefficient
23. Determination of Young's modulus and Poisson's ratio by Elliptical fringes - Cornu's Method
24. Determination of Stefan's constant of radiation from a hot body
25. Measurement of Coefficient of linear expansion- Air wedge Method
26. Measurement of Susceptibility of liquid - Quincke's method
27. B-H curve using CRO
28. Measurement of Magnetic Susceptibility - Guoy's method
29. LG Plate

30. Arc spectrum: Copper
31. Determination of Solar constant
32. Determination of e/m - Millikan's method
33. Miscibility measurements using ultrasonic diffraction method
34. Determination of Thickness of thin film. - Michelson Interferometer
35. GM counter – Feather's analysis: Range of Beta rays
36. Iodine absorption spectra
37. Molecular spectra – CN bands
38. Determination of Refractive index of liquids using diode Laser/ He – Ne Laser
39. Determination of Numerical Apertures and Acceptance angle of optical fibers using Laser Source.
40. Measurement of Dielectricity - Microwave test bench
41. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility
42. Interpretation of vibrational spectra of a given material

Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Practical Physics, S.L.Gupta and V.Kumar, Pragati Edition,2018. 2. An Advanced Course in Practical Physics - D. Chattopadhyay, P. C. Rakshit; New Central Book Agency (P) Ltd; 8th Edition, 2007. 3. A Textbook of Advanced Practical Physics - S. K. Ghosh; New Central; Fourth Edition, 2000.
REFERENCE BOOKS	1. Physical Methods, Instruments and Measurements - Vol. 1-4, - Yuri M. Tsipenyuk; Russian Academy of Sciences, Russia, 2009. 2. Encyclopedia of Physical Science and Technology: Measurements Techniques and Instrumentation - Robert Allen Meyers Academic Press, 2007.

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the strength of material using Young's modulus
CO2	Acquire knowledge of thermal behaviour of the materials
CO3	Understand theoretical principles of magnetism through the experiments.

PAPER 04 - QUANTUM MECHANICS	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C04	**QUANTUM MECHANICS**	Core	5	1	0	5	6	75

Learning Objectives
➢ To develop the physical principles and the mathematical background important to quantum mechanical descriptions. ➢ To describe the propagation of a particle in a simple, one-dimensional potential. ➢ To formulate and solve the Schrodinger's equation to obtain eigenvectors and energies for particle in a three-dimensional potential. ➢ To explain the mathematical formalism and the significance of constants of motion, and see their relation to fundamental symmetries in nature ➢ To discuss the Approximation methods like perturbation theory, Variational and WKB methods for solving the Schrödinger equation.

UNITS	Course Details
UNIT I: BASIC FORMALISM	Interpretation of the wave function – Time dependent Schrodinger equation –Time independent Schrodinger equation – Stationary states – Ehrenfest's theorem – Linear vector space – Linear operator – Eigen functions and Eigen values – Hermitian operator – Postulates of quantum mechanics – Simultaneous measurability of observables – General uncertainty relation
UNIT II: 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 – Hydrogen atom – Rigid rotator
UNIT III: GENERAL FORMALISM	Dirac notation – Equations of motions – Schrodinger representation – Heisenberg representation – Interaction representation – Coordinate representation – Momentum representation – Symmetries and conservation laws – Unitary transformation – Parity and time reversal
UNIT IV: APPROXIMATION METHODS	Time independent perturbation theory for non-degenerate energy levels – Degenerate energy levels – Stark effect in hydrogen atom – Ground and excited state – Variation method – Helium atom – WKB approximation – Connection formulae (no derivation) – WKB quantization – Application to simple harmonic oscillator.
UNIT V: ANGULAR MOMENTUM	Eigenvalue spectrum of general angular momentum – Ladder operators and their algebra – Matrix representation – Spin angular momentum – Addition of angular momenta – CG coefficients – Symmetry and anti – symmetry of wave functions – Construction of wave-functions and Pauli's exclusion principle.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. A Text book of Quantum Mechanics-P. M. Mathews and K. Venkatesan, McGraw Hill Education, 2nd Edition, 2017. 2. Quantum Mechanics- G. Aruldhas, Prentice Hall of India, 2nd Edition, 2013. 3. Introduction to Quantum Mechanics- David J. Griffiths and Darrell F. Schroeter, Cambridge University Press, 4th Edition, 2019. 4. Quantum Mechanics- Satya Prakash and Swati Saluja, Kedar Nath, Ram Nath and Co. Publications, 2019. 5. Quantum Mechanics: Theory and Applications- 5. A. Ghatak and S. Lokanathan, Kluwer Academic Publishers, 2004.
REFERENCE BOOKS	1. Quantum Mechanics- E. Merzbacher, John Wiley and Sons, New York, 2nd Edition,1970. 2. Quantum Mechanics- V. K. Thankappan, Wiley Eastern Ltd, New Delhi, 2nd Edition, 1985. 3. Quantum Mechanics - L. D. Landau and E. M. Lifshitz, Pergomon Press, Oxford, 1st Edition, 1976. 4. Quantum Mechanics- S. N. Biswas, Books and Allied Ltd., Kolkata, 1999. 5. Quantum Mechanics- V. Devanathan, Alpha Science International Ltd, Oxford, 2nd Edition, 2011.
WEB SOURCES	1. https://ocw.mit.edu/courses/8-04-quantum-physics-i-spring-2013/ 2. https://arxiv.org/archive/quant-ph 3. https://sites.google.com/site/thequantumbook/home/links-to-quantum-mechanics-and-related-physics-web-sites 4. https://testbook.com/physics/quantum-mechanics 5. https://www.youtube.com/watch?v=FsqTCpFBKfE&t=775s

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Demonstrates a clear understanding of the basic postulates of quantum mechanics which serve to formalize the rules of quantum Mechanics	**K1 K2 K3 K4 K5 K6**
CO2	Is able to apply and analyze the Schrodinger equation to solve one dimensional problems and three dimensional problems	
CO3	Can discuss the various representations, space time symmetries and formulations of time evolution	
CO4	Can formulate and analyze the approximation methods for various quantum mechanical problems	
CO5	To apply non-commutative algebra for topics such as angular and spin angular momentum and hence explain spectral line splitting.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER -05 - NUMERICAL METHODS AND COMPUTER PROGRAMMING	I YEAR –SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C05	**NUMERICAL METHODS AND COMPUTER PROGRAMMING**	Core	5	1	0	5	6	75

Learning Objectives
➢ To make students to understand different numerical approaches to solve a problem. ➢ To understand the basics of programming ➢ To relate simultaneous linear equations and their matrix representation distinguish between various methods in solving simultaneous linear equations. ➢ To understand, how interpolation will be used in various realms of physics and apply to some simple problems the newton forward and backward interpolation ➢ To understand the basics of Fortran-programming and conditional statements.

UNITS	Course Details
UNIT I: SOLUTIONS OF EQUATIONS	Zeros or Roots of an equation - Non-linear algebraic equation and transcendental equations - Zeros of polynomials – Roots of polynomials, nonlinear algebraic equations and transcendental equations using Bisection and Newton-Raphson methods – Convergence of solutions in Bisection and Newton-Raphson methods – Limitations of Bisection and Newton-Raphson methods.
UNIT II: LINEAR SYSTEM OF EQUATIONS	Simultaneous linear equations and their matrix representation– Inverse of a Matrix – Solution of simultaneous equations by Matrix inversion method and its limitations – Gaussian elimination method – Gauss Jordan method – Inverse of a matrix by Gauss elimination method - Eigen values and eigenvectors of matrices – Direct method - Power method and Jacobi Method to find the Eigen values and Eigen vectors.
UNIT III: INTERPOLATION AND CURVE FITTING	Interpolation with equally spaced points - Newton forward and backward interpolation - Interpolation with unevenly spaced points - Lagrange interpolation – Curve fitting – Method of least squares – Fitting a polynomial.
UNIT IV: DIFFERENTIATION, INTEGRATION AND SOLUTION OF DIFFERENTIAL EQUATIONS	Numerical differentiation – Numerical integration – Trapezoidal rule – Simpson's rule – Error estimates – Gauss-Legendre, Gauss-Laguerre, Gauss-Hermite and Gauss-Chebyshev quadrature – solution of ordinary differential equations – Euler and RungaKutta methods.
UNIT V: PROGRAMMING WITH FORTRAN	Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Creation of executable programs. – Programs for the following computational methods: (a) Zeros of polynomials by the bisection method, (b) Zeros of polynomials/non-linear equations by the Newton-Raphson method, (c) Newton's forward and backward

	interpolation, Lagrange Interpolation, (d) Trapezoidal and Simpson's Rules, (e) Solution of first order differential equations by Euler's method.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. V. Rajaraman, Computer oriented Numerical Methods, PHI Publishers, 3rd Edition, New Delhi, 1993. 2. M. K. Jain, S. R. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Intl., 3rd Edition, New Delhi, 1995. 3. S. S. Sastry, Introductory Methods of Numerical analysis, PHI, 5th edition, New Delhi, 2012. 4. F. Scheid, Numerical Analysis, McGraw Hill, 2nd Edition New York, 1998. 5. W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery,Numerical Recipes in FORTRAN, 2nd Edition, Cambridge Univ. Press, 1992.
REFERENCE BOOKS	1. S. D. Conte and C. de Boor, Elementary Numerical analysis-an algorithmic approach, McGraw Hill, 3rd Edition, 1981. 2. B. F. Gerald, and P. O. Wheatley, Applied Numerical analysis, 7th Edition, Addison-Wesley, 2004. 3. B. Carnagan, H. A. Luther and J. O. Wilkes, Applied Numerical Methods, Wiley, New York, 1969. 4. S. S. Kuo, Numerical Methods and Computers, Addison-Wesley, 1996. 5. V. Rajaraman, Programming in FORTRAN / Programming in C, PHI, New Delhi.
WEB SOURCES	1. https://www.scribd.com/doc/202122350/Computer-Oriented-Numerical-Methods-by-V-RajaRaman 2. https://www.scirp.org/(S(lz5mqp453edsnp55rrgjct55))/reference/referencespapers.aspx?referenceid=1682874 3. https://nptel.ac.in/course/122106033/ 4. https://nptel.ac.in/course/103106074/ 5. https://onlinecourses.nptel.ac.in/noc20_ma33/preview

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Recall the transcendental equations and analyze the different root finding methods. Understand the basic concept involved in root finding procedure such as Newton Raphson and Bisection methods, their limitations.	**K1 K2 K3 K4 K5 K6**
CO2	Relate Simultaneous linear equations and their matrix representation Distinguish between various methods in solving simultaneous linear equations.	
CO3	Understand, how interpolation will be used in various realms of physics and Apply to some simple problems Analyze the newton forward and backward interpolation	
CO4	Recollect and apply methods in numerical differentiation and integration. Assess the trapezoidal and Simson's method of numerical integration.	
CO5	Understand the basics of Fortran-programming and conditional statements.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER 6 - PRACTICAL – II – ELECTRONICS, MICROPROCESSOR AND MICROCONTROLLER	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C06	**PRACTICAL – II - ELECTRONICS, MICROPROCESSOR AND MICROCONTROLLER**	Core	0	0	6	4	6	75

Learning Objectives

- To observe the applications of FET and UJT.
- To study the different applications of operational amplifier circuits.
- To understand the concept of mechanical behavior of materials and calculation of same using appropriate equations.
- To write and verify the assembly language program using microprocessor 8085 for various applications.
- To write the assembly language program using microcontroller 8051.

Course Details

(Any Twelve Experiments)

1. Construction of relaxation oscillator using UJT
2. FET CS amplifier- Frequency response, input impedance, output impedance
3. Study of important electrical characteristics of IC741.
4. V- I Characteristics of different colours of LED.
5. Study of attenuation characteristics of Wien's bridge network and design of Wien's bridge oscillator using Op-Amp.
6. Study of attenuation characteristics of Phase shift network and design of Phase shift oscillator using Op-Amp.
7. Construction of Schmidt triggers circuit using IC 741 for a given hysteresis- application as squarer.
8. Construction of square wave Triangular wave generator using IC 741
9. Construction of pulse generator using the IC 741 – application as frequency divider
10. Construction of Op-Amp- 4 bit Digital to Analog converter (Binary Weighted and R/2R ladder type)
11. Study of Binary to Gray and Gray to Binary code conversion.
12. Study of R-S, clocked R-S and D-Flip flop using NAND gates
13. Study of J-K, D and T flip flops using IC 7476/7473
14. Arithmetic operations using IC 7483- 4-bit binary addition and subtraction.
15. Study of Arithmetic logic unit using IC 74181.
16. Construction of Encoder and Decoder circuits using ICs.
17. IC 7490 as scalar and seven segment display using IC7447
18. Solving simultaneous equations – IC 741 / IC LM324
19. Op-Amp –Active filters: Low pass, High pass and Band pass filters (Second Order) Batter worth filter

20. Construction of Current to Voltage and Voltage to Current Conversion using IC 741.
21. Realization of analog to digital converter (ADC) using 4-bit DAC and synchronous counter IC74193
22. Construction of square wave generator using IC 555 – Study of VCO
23. Construction of Schmidt trigger circuit using IC555 for a given hysteresis – Application as squarer
24. Construction of pulse generator using the IC 555 – Application as frequency divider
25. BCD to Excess- 3 and Excess 3 to BCD code conversion
26. Shift register and Ring counter and Johnson counter- IC 7476/IC 7474
27. Construction of Multiplexer and Demultiplexer using ICs.

Microprocessor 8085:

28. Arithmetic operations- 8 bit and 16 bit
29. Code conversion (BCD to Binary and Binary to BCD).
30. Arranging numbers in ascending and descending orders.
31. Temperature Conversions (F to C & C to F).
32. Determination of factorial of the given number.
33. Square and square root of the given number.
34. Sum of the "n" numbers.
35. ALP to control and modify Traffic light signal.
36. controlled rotation of the shaft of a stepper motor.

Microcontroller 8051:

37. Array operations (Biggest and Smallest number).
38. Square and square root of the given number.
39. Stepper motor interfacing.
40. Seven segment display.

TEXT BOOKS	1. Practical Physics, Gupta and Kumar, Pragati Prakasan,2017. 2. Kit Developed for doing experiments in Physics- Instruction manual, R. Srinivasan K.R Priolkar, Indian Academy of Sciences,2001. 3. Op-Amp and linear integrated circuit, Ramakanth A Gaykwad, Eastern Economy Edition,2002. 4. Electronic lab manual Vol I, K A Navas, Rajath Publishing,2006. 5. Electronic lab manual Vol II, K A Navas, PHI eastern Economy Edition 2007.
REFERENCE BOOKS	1. An advanced course in Practical Physics, D. Chattopadhayay, C. R Rakshit, New Central Book Agency Pvt. Ltd, 2011. 2. Advanced Practical Physics, S.P Singh, Pragati Prakasan,2017. 3. A course on experiment with He-Ne Laser, R. S. Sirohi, John Wiley & Sons (Asia) Pvt. Ltd,1991. 4. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing,2010. 5. Electronic Laboratory Primer a design approach, S. Poornachandra, B. Sasikala, Wheeler Publishing, New Delhi,2005.

METHOD OF EVALUATION:

Continuous Internal Assessment	End Semester Examination	Total	Grade
25	75	**100**	

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Acquire knowledge of thermal behavior of the materials.	**K1**
CO2	Understand theoretical principles of magnetism through the experiments.	**K2**
CO3	Acquire knowledge about assembly language program using 8085.	**K3**
CO4	Improve the analytical and observation ability in Physics Experiments.	**K4**
CO5	Acquire knowledge in microprocessor and microcontroller.	**K5** **K6**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	S	S
CO2	2	2	S	S	S
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3

PAPER - 7 - ELECTROMAGNETIC THEORY	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C07	**ELECTROMAGNETIC THEORY**	Core	5	1	0	5	6	75

Learning Objectives
➢ To acquire knowledge about boundary conditions between two media and the technique of method of separation of variables
➢ To understand Biot – Savart's law and Ampere's circuital law
➢ To comprehend the physical ideas contained in Maxwell's equations, Coulomb & Lorentz gauges, conservation laws
➢ To assimilate the concepts of propagation, polarization, reflection and refraction of electromagnetic waves
➢ To grasp the concept of plasma as the fourth state of matter

UNITS	Course Details
UNIT I: 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.
UNIT II: MAGNETOSTATICS	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.
UNIT III: 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.
UNIT IV: 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
UNIT V: ELEMENTARY PLASMA PHYSICS	The Boltzmann Equation - Simplified magneto-hydrodynamic equations - Electron plasma oscillations - The Debye shielding problem - Plasma confinement in a magnetic field - Magneto-hydrodynamic waves - Alfven waves and magnetosonic waves.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Introduction to Electrodynamics – David J. Griffiths, 4th Edition, Pearson, 2012. 2. Electromagnetic Theory and Electrodynamics –Sathya Prakash, Kedar Nath Ram Nath and Co, 2017. 3. Electromagnetics - B.B Laud, Wiley Eastern Company, 2000. 4. Fundamentals of Electromagnetic -Wazed Miah, Tata Mc Graw Hill, 1980. 5. Basic Electromagnetics with Application - Narayana Rao, (EEE) Prentice Hall, 1997.
REFERENCE BOOKS	1. Fundamentals of Electromagnetic Theory – John R.Reitz, Frederick J Milford and Robert W.Christy, Third edition, Narosa Publishing House, New Delhi, 1998. 2. Classical Electrodynamics – J.D. Jackson, II Edition, Wiley Eastern Limited, 1993. 3. Electromagnetic Fields and Waves – P. Lorrain and D.Corson, 1987. 4. Electromagnetics, B.B Laud, Wiley Eastern Company, 2000.
WEB SOURCES	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 _Tuto rials/ 5. https://www.cliffsnotes.com/study-guides/physics/electricity-and-magnetism/electrostatics

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Solve the differential equations using Laplace equation and to find solutions for boundary value problems	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER 08 - SPECTROSCOPY	II YEAR – III SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C08	SPECTROSCOPY	Core	5	1	0	5	6	75

Learning Objectives

- To comprehend the theory behind different spectroscopic methods
- To know the working principles along with an overview of construction of different types of spectrometers involved
- To explore various applications of these techniques in R &D.
- Apply spectroscopic techniques for the qualitative and quantitative analysis of various chemical compounds.
- Understand this important analytical tool

UNITS	Course Details
UNIT I: **ELECTRONIC SPECTROSCOPY**	Quantum states of an atom - Electronic wave functions – Shape of atomic orbitals - Atomic quantum numbers – Hydrogen atom spectrum – Relativistic corrections of energy levels - Spectrum of lithium and helium atoms – LS and JJ couplings – Selection rules - Hyperfine structure – Isotopic shift – Width of spectral lines - Zeeman effect – Paschen-Back effect – Stark effect - Electronic spectra of diatomic molecules – Born- Oppenheimer approximation – Vibrational course structure – Frank- Condon principle
UNIT II: **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 - Hyperfine structure and quadrupole moment of linear molecules - Instrumentation techniques – block diagram -Information derived from rotational spectra - Problems.
UNIT III: **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– Remote analysis of atmospheric gases like N_2O using FTIR by National Remote Sensing Centre (NRSC), India– Other simple applications
UNIT IV: **RAMAN SPECTROSCOPY**	Theory of Raman scattering - Classical theory – molecular polarizability – polarizability ellipsoid - Quantum theory of Raman effect - rotational Raman spectra of linear molecules - symmetric top molecules – Stokes and anti-stokes line- SR branch -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 and Raman techniques - FT Raman spectroscopy- SERS
UNIT V: **RESONANCE SPECTROSCOPY**	Nuclear and electron spin-Interaction with magnetic field - Population of energy levels - Larmor precession- Relaxation times - Double resonance- Chemical shift and its measurement - NMR of hydrogen nuclei - Indirect spin -spin interaction – interpretation of NMR spectra of simple organic molecules - Instrumentation techniques of NMR spectroscopy – NMR in Chemical industries- MRI Scan 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
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Fundamentals of Molecular Spectroscopy, C N Banwell and E M McCash, Tata McGraw–Hill, New Delhi, 4th Edition,1994. 2. Molecular Structure and Molecular Spectroscopy, G Aruldhas, Prentice–Hall of India, New Delhi, 1994. 3. Vibrational Spectroscopy and Applications, D.N. Satyanarayana, New Age International Publication,2001 4. Spectroscopy, B.K. Sharma, Goel Publishing House Meerut, 2015. 5. Spectroscopy of Organic Compounds, P.S. Kalsi., New Age International Publishers, 7th Edition, 2016
REFERENCE BOOKS	1. Molecular Spectroscopy, J L McHale, Pearson Education India, New Delhi, 2008. 2. Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry, J M Hollas, Royal Society of Chemistry, RSC, Cambridge, 2002. 3. Spectroscopy Vol. I, B. P. Straughan and S. Walker, Chapman and Hall, New York, 1976. 4. Introductory Quantum Chemistry, K. Chandra, Tata McGraw Hill, New Delhi, 1989. 5. Laser Spectroscopy: Basic concepts and Instrumentation, W. Demtroder, Springer Link.
WEB SOURCES	1. https://www.youtube.com/watch?v=0iQhirTf2PI 2. https://www.coursera.org/lecture/spectroscopy/introduction-3N5D5 3. https://www.coursera.org/lecture/spectroscopy/infrared-spectroscopy-8jEee 4. https://onlinecourses.nptel.ac.in/noc20_cy08/preview 5. https://www.coursera.org/lecture/spectroscopy/nmr-spectroscopy-introduction-XCWRu

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand fundamentals of rotational spectroscopy, view molecules as elastic rotors and interpret their behaviour.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Understand the working principles of spectroscopic instruments and theoretical background of IR spectroscopy. Able to correlate mathematical process of Fourier transformations with instrumentation.	
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER 9 - STATISTICAL MECHANICS	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C09	**STATISTICAL MECHANICS**	Core	5	1	0	5	6	75

Learning Objectives
➢ To acquire the knowledge of thermodynamic potentials and to understand phase transition in thermodynamics ➢ To identify the relationship between statistic and thermodynamic quantities ➢ To comprehend the concept of partition function, canonical and grand canonical ensembles ➢ To grasp the fundamental knowledge about the three types of statistics ➢ To get in depth knowledge about phase transitions and fluctuation of thermodynamic properties that vary with time

UNITS	Course Details
UNIT I: STATISTICAL MECHANICS AND THERMODYNAMICS	Foundations of statistical mechanics - Specification of states of a system - Micro canonical ensembles - Phase space – Entropy - Connection between statistics and thermodynamics – Gibbs-Duhem relation for entropy - Thermodynamic potentials– Maxwell relations- Entropy of an ideal gas using the micro canonical ensembles - Entropy of mixing and Gibb's paradox.
UNIT II: CANONICAL AND GRAND CANONICAL ENSEMBLES	Trajectories and density of states - Liouville's theorem - Canonical and grand canonical ensembles - Partition function - Relation between grand canonical and canonical partition functions.- Energy and density fluctuations.
UNIT III: CLASSICAL AND QUANTUM STATISTICS	Statistics of indistinguishable particles - Maxwell-Boltzmann statistics - Maxwell-Boltzmann distribution law for microstates in a classical gas -Fermi-Dirac statistics – Ideal Fermi gas – Degeneracy - Bose-Einstein statistics - Non-interacting Bose gas and thermodynamic relations -Plank radiation formula - Ideal Bose gas - Bose-Einstein condensation.
UNIT IV: REAL GAS, ISING MODEL AND TRANSPORT PROCESS	Cluster expansion for a classical gas - Virial equation of state – Calculation of the first Virial coefficient in the cluster expansion - Ising model - Mean-field theories of the Ising model in one dimensions - Exact solutions in one dimension. -transport phenomena Random walk - - Brownian motion - All speeds and all directions

UNIT V: HEAT CAPACITIES AND PHASE TRANSITIONS	Heat capacities of heteronuclear diatomic gas – Heat capacities of homonuclear diatomic gas- Heat capacity of Bose gas – Phase Equilibrium - Gibb's phase rule - Phase transitions – Landau's theory of phase transition - Classification of phase transitions by order and by symmetry –Critical indices
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Statistical Mechanics, S. K. Sinha, Tata McGraw Hill, New Delhi, 1990 2. Statistical Mechanics, B. K. Agarwal and M. Eisner, Second Edition, New Age International, New Delhi, 1998 3. Statistical Mechanics: An Introductory Text, J. K. Bhattacharjee, Allied Publication, New Delhi, 1996 4. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw-Hill, New York, 1965 5. Heat and Thermodynamics, M. K. Zemansky, 5th edition, McGraw-Hill, New York, 1968
REFERENCE BOOKS	1. Statistical Mechanics, R. K. Pathria, 2nd edition, Butterworth-Heinemann, New Delhi, 1996 2. Statistical Physics, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1969 3. Statistical Mechanics, K. Huang, Taylor and Francis, London, 2002 4. Thermodynamics and Statistical Mechanics, W. Greiner, L. Neise, and H. Stoecker, Springer Verlag, New York, 2005 5. Thermal Physics, A. B. Gupta and H. Roy, Books and Allied, Kolkata, 2002
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

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	To examine and elaborate the effect of changes in thermodynamic quantities on the states of matter during phase transition	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	To analyze the macroscopic properties such as pressure, volume, temperature, specific heat, elastic moduli etc. using microscopic properties like intermolecular forces, chemical bonding, atomicity etc. Describe the peculiar behaviour of the entropy by mixing two gases Justify the connection between statistics and thermodynamic quantities	
CO3	Differentiate between canonical and grand canonical ensembles and to interpret the relation between thermodynamical quantities and partition function	
CO4	To recall and apply the different statistical concepts to analyze the behaviour of ideal Fermi gas and ideal Bose gas and also to compare and distinguish between the three types of statistics.	
CO5	To discuss and examine the thermodynamical behaviour of gases under fluctuation and also using Ising model	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER - 10 - PRACTICAL – III - COMPUTATIONAL PROGRAMMING AND SIMULATION	II YEAR - THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C10	**COMPUTATIONAL PROGRAMMING AND SIMULATION**	Core	0	0	6	4	6	75

Learning Objectives

- The aim and objective of the course on Computational Practical is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using any high level language such as FORTRAN
- To equip the computational skill using various mathematical tools.
- To apply the software tools to explore the concepts of physical science.
- To approach the real time activities using physics and mathematical formulations.

Course Details

(Any Twelve Experiments)

1. Lagrange interpolation with Algorithm, Flow chart and output.
2. Newton forward interpolation with Algorithm, Flow chart and output.
3. Newton backward interpolation with Algorithm, Flow chart and output.
4. Curve-fitting: Least squares fitting with Algorithm, Flow chart and output.
5. Numerical integration by the trapezoidal rule with Algorithm, Flow chart and output.
6. Numerical integration by Simpson's rule with Algorithm, Flow chart and output.
7. Numerical solution of ordinary first-order differential equations by the Euler method with Algorithm, Flow chart and output.
8. Numerical solution of ordinary first-order differential equations by the Runge- Kutta method with Algorithm, Flow chart and output.
9. Finding Roots of a Polynomial - Bisection Method –
10. Finding Roots of a Polynomial - Newton Raphson Method –
11. Solution of Simultaneous Linear Equation by Gauss elimination method.
12. Solution of Ordinary Differential Equation by Euler
13. Runge Kutta Fourth Order Method for solving first order Ordinary Differential Equations
14. Newton's cotes formula
15. Trapezoidal rule
16. Simpson's 1/3 rule
17. Simpson's 3/8 rule
18. Boole's rule
19. Gaussian quadrature method (2 point and 3 point formula)
    Giraffe's root square method for solving algebraic equation

TEXT BOOKS	1. Numerical methods using Matlab – John Mathews & Kurtis Fink, Prentice Hall, New Jersey, 4th edition, 2006. 2. Numerical methods in Science and Engineering - M.K. Venkataraman, National Publishing Co. Madras, Fifth edition, 1999. 3. Computer Oriented Numerical Methods, V. Rajaraman, PHI learning, Fourth edition, 2019. 4. Numerical Methods for Scientific and Engineering Computation, M.K. Jain, S.R. Iyengar and R.K. Jain, New Age International, Sixth edition, 2012. 5. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI, 5th edition, 2012.
REFERENCE BOOKS	1. Elementary Numerical Analysis, Updated with MATLAB (Classics in Applied Mathematics), S.D. Conte and C. de Boor, Society for Industrial & Applied Mathematics, Latest Edition, 2018. 2. Applied Numerical Analysis, B.F. Gerald and P.O. Wheately, Addison Wesley Reading, 5th Edition, 1994. 3. Applied Numerical Methods, B. Carnahan, H.A. Luther and J.O. Wikes, Wiley, 1st edition, 1969. 4. Numerical Methods and Computers, S.S. Kuo, Addison - Wesley, London, 1996. 5. Programming in FORTRAN/ Programming in C, V. Rajaraman PHI, , New Delhi, 1997.

METHOD OF EVALUATION:

Continuous Internal Assessment	End Semester Examination	Total	Grade
25	75	**100**	

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Use various numerical methods in describing/solving physics problems.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.	
CO3	Enhance the problem-solving aptitudes of students using various numerical methods.	
CO4	Apply various mathematical entities, facilitate to visualise any complicate tasks.	
CO5	Identify modern programming methods and describe the extent and limitations of computational methods in physics	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	2	3	3
CO2	2	2	3	3	3
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	3

PAPER 11 – NUCLEAR AND PARTICLE PHYSICS	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C11	NUCLEAR AND PARTICLE PHYSICS	Core	5	1	0	5	6	75

Learning Objectives

- Introduces students to the different models of the nucleus in a chronological order
- Imparts an in-depth knowledge on the nuclear force
- Introduces the types of nuclear reactions and their principles
- Provides students with details of nuclear decay with relevant theories
- Exposes students to the Standard Model of Elementary Particles and Higgs boson.

UNITS	Course Details
UNIT I: **NUCLEAR MODELS**	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 – Schmidt model – Electric Quadrapole moment - Bohr and Mottelson collective model – Rotational and vibrational bands.
UNIT 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 – Nucleon-nucleon scattering – Effective range theory – Spin dependence of nuclear forces - Charge independence and charge symmetry – Isospin formalism.
UNIT 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.
UNIT IV: **NUCLEAR DECAY**	Alpha 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.
UNIT 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.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Nuclear Physics , D.C. Tayal, Himalaya Publishing House, 2011 . 2. Introductory Nuclear Physics , K. S. Krane, John Wiley & Sons ,2008. 3. Nuclear Physics , R. Roy and P. Nigam, New Age Publishers, 1996. 4. Nuclear Physics – An introduction , S. B. Patel , New Age International Pvt Ltd Publishers, 2011. 5. Source Book of Atomic Energy, S. Glasstone, Van Nostrand Reinhold Inc.,U.S., 3rd Revised edition, 1968.
REFERENCE BOOKS	1. The Physics of elementary particles, L. J. Tassie , Prentice Hall Press, 1973. 2. Introduction to Nuclear Physics, H. A. Enge, Addison Wesley, Publishing Company. Inc. Reading. New York, 1974. 3. Nuclear Physics , Kaplan , Narosa –2nd Edition, 2002. 4. Concepts of Nuclear Physics , Bernard L Cohen, McGraw Hill Education (India) Private Limited, 1 edition, 2001. 5. Concepts of Nuclear Physics, B.L. Cohen, TMCH, New Delhi, 1971.
WEB SOURCES	1. http://bubl.ac.uk/link/n/nuclearphysics.html 2. http://www.phys.unsw.edu.au/PHYS3050/pdf/Nuclear_Models.pdf http://www.scholarpedia.org/article/Nuclear_Forces 3. https://www.nuclear-power.net/nuclear-power/nuclear-reactions/ 4. http://labman.phys.utk.edu/phys222core/modules/m12/nuclear_models.html 5. https://www.ndeed.org/EducationResources/HighSchool/Radiography/radioactivedecay.html

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion.	**K1 K2 K3 K4 K5 K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

PAPER 12 - CONDENSED MATTER PHYSICS	II YEAR – FOURTH SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1C12	**CONDENSED MATTER PHYSICS**	Core	5	1	0	5	6	75

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

UNITS	Course Details
UNIT I: CRYSTAL PHYSICS	Types of lattices - Miller indices –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 - Ewald's sphere construction
UNIT II: LATTICE DYNAMICS AND THERMAL PROPERTIES	Lattice with two atoms per primitive cell - First Brillouin zone - Group and phase velocities - Theory of vibrations of monoatomic and diatomic lattices- Acoustical, optical, transverse and longitudinal modes - Phonon momentum - Inelastic scattering by phonons - Debye's theory of lattice heat capacity - Thermal conductivity - Umkalapp processes - Specific heat capacity of solids-Einstein & Debye models
UNIT III: THEORY OF METALS AND SEMICONDUCTORS	Free electron gas in three dimensions - Electronic heat capacity - Band theory of metals and semiconductors - Bloch theorem - Nearly free electron model-Kronig-Penney model - Semiconductors - Intrinsic carrier concentration – Temperature dependence - Mobility - Impurity conductivity – Impurity states - Hall effect - Fermi surfaces and construction - Hall effect- Thermo electric power.
UNIT IV: DIELECTRICS AND MAGNETISM	Types of polarization- Clausius-Mossotti relation -Diamagnetism - Quantum theory of paramagnetism -Quenching of orbital angular momentum - Curie point - Heisenberg's interpretation of Weiss field - Ferromagnetic domains - Spin waves - Quantization - Magnons -

	Thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of antiferomagnetism - Neel temperature- Spintronics
UNIT V: Superconductivity	**Experimental facts:** Occurrence - Effect of magnetic fields - Meissner effect – Critical field – Critical current - Entropy and heat capacity - Energy gap - Type I and II superconductors. **Theoretical Explanation:** Thermodynamics of superconducting transition - London equation - Coherence length – Isotope effect - Cooper pairs – Bardeen Cooper Schrieffer (BCS) Theory - Single particle tunneling - Josephson tunneling - DC and AC Josephson effects - High temperature superconductors – SQUIDS.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Introduction to Solid State Physics, C. Kittel, 8th Edition, Wiley, New York, 2012 2. Solid State Physics, Rita John, Tata McGraw Hill Publication, 2014 3. Solid State Physics, A. J. Dekker, Macmillan India, New Delhi, 2008 4. Elementary Solid State Physics – Principles and Applications, M. Ali Omar, Addison-Wesley, 1974 5. Introductory Solid State Physics, H. P. Myers, 2nd Edition, Viva Book, New Delhi, 1998
REFERENCE BOOKS	1. Solid State Physics, J. S. Blakemore, 2nd Edition, W.B. Saunders, Philadelphia, 1974 2. The Solid State, H. M. Rosenburg, 3rd Edition, Oxford University Press, Oxford, 1993 3. Principles of the Theory of Solids, J. M. Ziman, Cambridge University Press, London, 1971 4. Introduction to Superconductivity, C. Ross-Innes and E. H. Rhoderick, Pergamon, Oxford, 1976 5. Elements of Solid State Physics, J. P. Srivastava, Prentice-Hall of India, New Delhi, 2001
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/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure	**K1 K2 K3 K4 K5**
CO2	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.	
CO3	Student will be able to comprehend the heat conduction in solids	
CO4	Student will be able to generalize the electronic nature of solids from band theories.	
CO5	Student can compare and contrast the various types of magnetism and conceptualize the idea of superconductivity.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE COURSES

ELECTIVE - LIST 1 – 1. LINEAR AND DIGITAL ICs & APPLICATIONS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E01	**LINEAR AND DIGITAL ICs AND APPLICATIONS**	Elective	4	1	0	3	5	75

Learning Objectives
➢ To introduce the basic building blocks of linear integrated circuits. ➢ To teach the linear and non-linear applications of operational amplifiers. ➢ To introduce the theory and applications of PLL. ➢ To introduce the concepts of waveform generation and introduce one special function ICs. ➢ Exposure to digital IC ‘s

UNITS	Course Details
UNIT I: INTEGRATED CIRCUITS AND OPERATIONAL AMPLIFIER	Introduction, Classification of IC ‘s, basic information of Op-Amp 741 and its features, the ideal Operational amplifier, Op-Amp internal circuit and its Characteristics.
UNIT II: 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.
UNIT III: ACTIVE FILTERS & TIMER AND PHASE LOCKED LOOPS	**Active Filters**: Introduction, Butterworth filters – 1st order, 2nd order low pass and high pass filters, band pass and all filters. **Timer and Phase Locked Loops:** Introduction to IC 555 timer, description of functional diagram, monostable and astable operations and applications, Schmitt trigger, PLL - introduction, basic principle, phase detector/comparator, voltage controlled oscillator (IC 566), low pass filter, monolithic PLL and applications.
UNIT IV: VOLTAGE REGULATOR & D to A AND A to D CONVERTERS	**Voltage Regulator**: Introduction, Series Op-Amp regulator, IC Voltage Regulators, IC 723 general purpose regulators, Switching Regulator. **D to A and A to D Converters**: 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.

UNIT V: **CMOS LOGIC, COMBINATIONAL CIRCUITS USING TTL 74XX ICs** & **SEQUENTIAL CIRCUITS USING TTL 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. **Combinational Circuits Using TTL 74xx Ics:** Study of logic gates using 74XX ICs, Four-bit parallel adder (IC 7483), Comparator (IC 7485), Decoder (IC 74138, IC 74154), BCD to 7-segment decoder (IC7447), Encoder (IC74147), Multiplexer (IC74151), Demultiplexer (IC 74154). **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).
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Linear Integrated Circuit-D. Roy Choudhury, Shail B. Jain, New Age International Pvt. Ltd., New Delhi, India, 4th edition, 2012 2. OP-AMP and Linear Integrated Circuits-Ramakant A. Gayakwad, Prentice Hall / Pearson Education, New Delhi, 4th edition, 2012. 3. A Textbook of Electrical technology, B.L. Theraja and A.K. Theraja, S. Chand & Co, 2004. 4. Principles of Electronics, V.K. Mehta and Rohit Mehta, S. Chand & Co, 12th Edition, 2008. 5. Introduction to Integrated electronics (Digital & Analog),V. Vijayendran, S. Viswanathan Printers & Publishers Private Ltd, Reprint. V, 2008.
REFERENCE BOOKS	1. Design with operational amplifiers and analog integrated circuits Sergio Franco, McGraw Hill, New Delhi. 1997. 2. Analysis and Design of Analog Integrated Circuits, Gray, Meyer, Wiley International, New Delhi. 1995. 3. Digital Principles and Applications Malvino and Leach Tata ,McGraw Hill, New Delhi,5th Edition, 2005 4. Digital Fundamentals -Floyd, Jain, Pearson Education, New Delhi, 8th edition 2009. 5. Integrated Electronics, Millman & Halkias, Tata McGraw Hill, 17th Reprint 2000
WEB SOURCES	1. https://nptel.ac.in/course.html/digital circuits/ 2. https://nptel.ac.in/course.html/electronics/operational amplifier/ 3. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-7/field-effect-controlled-thyristors/ 4. https://www.electrical4u.com/applications-of-op-amp/ 5. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Learn about the basic concepts for the circuit configuration for the design of linear integrated circuits and develops skill to solve problems	**K1 K2 K3 K4 K5 K6**
CO2	Develop skills to design linear and non-linear applications circuits using Op-Amp and design the active filters circuits.	
CO3	Gain knowledge about PLL, and develop the skills to design the simple circuits using IC 555 timer and can solve problems related to it.	
CO4	Learn about various techniques to develop A/D and D/A converters.	
CO5	Acquire the knowledge about the CMOS logic, combinational and sequential circuits	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 1 - 2. PHYSICS OF NANOSCIENCE AND TECHNOLOGY

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E02	**PHYSICS OF NANOSCIENCE AND TECHNOLOGY**	Elective	4	1	0	3	5	75

Learning Objectives

- Physics of nanoscience and technology is concerned with the study, creation, manipulation and applications at nanometer scale.
- To provide the basic knowledge about nanoscience and technology.
- To learn the structures and properties of nanomaterials.
- To acquire the knowledge about synthesis methods and characterization techniques and its applications.
- To apply the concepts of nanoscience and technology in the field of sensors, robotics, purification of air and water and in the energy devices

UNITS	Course Details
UNIT 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.
UNIT 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).
UNIT 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.
UNIT 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.
UNIT 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.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. A textbook of Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw-Hill Publishing, 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, Nanotechnology, Wiley Publishing Inc. USA, 2005. 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. 5. The Nanoscope Encyclopedia of Nanoscience and Nanotechnology, Parag Diwan and Ashish Bharadwaj, Pentagon Press, New Delhi, 2005.
WEB SOURCES	1. www.its.caltec.edu/feyman/plenty.html 2. http://www.library.ualberta.ca/subject/nanoscience/guide/index.cfm 3. http://www.understandingnano.com 4. http://www.nano.gov 5. http://www.nanotechnology.com

COURSE OUTCOMES:

At the end of the 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.	**K1** **K2** **K3** **K4** **K5** **K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	1	1
CO2	3	3	3	1	1
CO3	3	3	2	1	1
CO4	3	3	3	1	1
CO5	3	3	2	1	1

ELECTIVE - LIST 1 – 3. ENERGY PHYSICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E03	**ENERGY PHYSICS**	Elective	4	1	0	3	5	75

Learning Objectives
➢ To learn about various renewable energy sources. ➢ To know the ways of effectively utilizing the oceanic energy. ➢ To study the method of harnessing wind energy and its advantages. ➢ To learn the techniques useful for the conversion of biomass into useful energy. ➢ To know about utilization of solar energy.

UNITS	Course Details
UNIT I: **INTRODUCTION TO ENERGY SOURCES**	Conventional and non-conventional energy sources and their availability– Prospects of Renewable energy sources– Energy from other sources– chemical energy–Nuclear energy– Energy storage and distribution.
UNIT 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.
UNIT III: **WIND ENERGY SOURCES**	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.
UNIT 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.
UNIT V: **SOLAR ENERGY SOURCES**	Solar radiation and its measurements–solar cells: Solar cells for direct conversion of solar energy to electric powers–solar cell parameter–solar cell electrical characteristics– Efficiency–solar water Heater –solar distillation–solar cooking–solar greenhouse – Solar pond and its applications.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Non – convention energy sources, G. D. Rai, Khanna publishers, 5th edition, 1998. 2. Energy technology, S. Rao and Dr. Paru Lekar, Khanna publishers, 3rd edition, 1994. 3. Solar Energy, M.P. Agarwal, S. Chand and Co,1983. 4. Solar energy, principles of thermal collection and storage, S. P. Sukhatme, Tata McGraw-Hill Publishing Co. Lt., 2nd edition, 1997. 5. Energy Technology, S. Rao and Dr. Parulekar, Khanna publishers, 3rd edition, 1994.
REFERENCE BOOKS	1. Renewable energy resources, John Twidell and Tonyweir, Taylor and Francis group, 3rd Edition, 2015. 2. Applied solar energy, A. B. Meinel and A. P. Meinal, Addison-Wesley Publishing Company, 1977. 3. Renewal Energy Technologies: A Practical Guide for Beginners, C.S. Solanki, PHI Learning, 2008. 4. Introduction to Non-Conventional Energy Resources, A.K.Raja et. al., Sci. Tech Publications, 2015.
WEB SOURCES	1. https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=2411&printable=1 2. https://www.nationalgeographic.org/encyclopedia/tidal-energy/ 3. https://www.ge.com/renewableenergy/wind-energy/what-is-wind-energy 4. https://www.reenergyholdings.com/renewable-energy/what-is-biomass/ 5. https://www.acciona.com/renewable-energy/solar-energy/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Identify various forms of renewable and non-renewable energy sources	**K1** **K2** **K3** **K4** **K5** **K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 1 – 4. CRYSTAL GROWTH AND THIN FILMS								
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
23UPPHY1E04	**CRYSTAL GROWTH AND THIN FILMS**	Elective	4	1	0	3	5	75

Learning Objectives
➢ To acquire the knowledge on Nucleation and Kinetics of crystal growth ➢ To understand the Crystallization Principles and Growth techniques ➢ To study various methods of Crystal growth techniques ➢ To understand the thin film deposition methods ➢ To apply the techniques for the Characterization of materials

UNITS	**Course Details**
UNIT I: CRYSTAL GROWTH KINETICS	Basic Concepts, Nucleation and Kinetics of growth Ambient phase equilibrium - Super saturation - Equilibrium of finite phases equation of Gibbs - Thomson -Types of Nucleation - Formation of critical Nucleus - Classical theory of Nucleation - rate of Nucleation - epitaxial growth - Growth mechanism and classification - Kinetics of growth of epitaxial films
UNIT II: CRYSTALLIZATION PRINCIPLES and Solution Growth	Crystallization Principles - 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.
UNIT 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 - Flux growth - Hydrothermal growth - Vapour phase growth - Physical vapour deposition - Chemical vapour deposition.
UNIT 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.
UNIT V: CHARACTERIZATION TECHNIQUES	X–ray diffraction – Powder and single crystal – Fourier transform infrared analysis – Transmission– UV-Vis-NIR spectrometer – Vickers micro hardness –Basic principles and operations of SEM and TEM- Nonlinear Optical phenomenon (qualitative) - Kurtz powder SHG method.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	**1**. Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy, V. Markov, 2nd edition, 2004 2. Thin Film Fundamentals, A. Goswami, New Age, New Delhi, 2008 3. Modeling of Crystal Growth Rates from Solution, M. Ohora and R. C. Reid, 1973 4. Crystal Growth from High Temperature Solution, D. Elwell and H. J. Scheel, 1976 5. Crystal Growth in Gels, Heinz K. Henish, Cambridge University Press, USA, 1973
REFERENCE BOOKS	1. Crystal Growth Process, J.C. Brice, John Wiley, New York, 1986 2. UGC Summer School Notes, P. Ramasamy and F. D. Gnanam, 1983 3. Crystal Growth Processes, P. Santhana Raghavan and P. Ramasamy, KRU Publications, 2000 4. Crystal Growth, H.E. Buckley, John Wiley and Sons, New York, 1951 5. Crystal Growth, B.R. Pamplin, Pergamon Press, London, 1980
WEB SOURCES	1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRjLrXp3kMtrIO8kZl1D1Jp 2. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgwcy7Ke TLUuBu3WF 3. https://www.youtube.com/playlist?list=PLADLRin7kNjG1Dlna9MDA53 CMKFHPSi9m 4. https://www.youtube.com/playlist?list=PLXHedIxbyr8xIl_KQFs_R_oky3Yd1Emw 5. https://www.electrical4u.com/thermal-conductivity-of-metals/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Acquire the Basic Concepts, Nucleation and Kinetics of crystal growth	**K1** **K2** **K3** **K4** **K5**
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 to understand the properties of the materials	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 1 – 5. ANALYSIS OF CRYSTAL STRUCTURES

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E05	**ANALYSIS OF CRYSTAL STRUCTURES**	Elective	4	1	0	3	5	75

Learning Objectives
➢ To teach the concept of crystal structures and symmetry, and diffraction theory ➢ To provide students with a background to X-ray generation, scattering theory and experimental diffraction from single crystals ➢ To provide instruction on the methods and basis for determining low-molecular weight crystal structures using X-ray Crystallography ➢ To give the students a background to the instrumentation used for powder diffraction and structure refinement using Rietveld method ➢ To teach the different levels of structure exhibited by proteins and nucleic acids and methods used in protein crystallography.

UNITS	Course details
UNIT I: CRYSTAL LATTICE	Unit cell and Bravais lattices - Crystal planes and directions - Basic symmetry elements operations - Translational symmetries - Point groups - Space groups - Equivalent positions - Bragg's law - Reciprocal lattice concept -Laue conditions - Ewald and limiting spheres - Diffraction symmetry - Laue groups.
UNIT II: DIFFRACTION	X-ray generation, - Sealed tube, rotating anode, absorption - Filters and monochromators Atomic scattering factor - Fourier transformation and structure factor - Anomalous dispersion - Interpretation of diffraction patterns - Cell parameter determination - Systematic absences - Space group determination.
UNIT III: STRUCTURE ANALYSIS	Single crystal diffractometers - Geometries - Scan modes - Intensity data collection - Data reduction - Factors affecting X-ray intensities - Temperature and scale factor - Electron density - Phase problem - normalized structure factor - Direct method fundamentals and procedures -Patterson function and heavy atom method - Structure refinement - Least squares method - Fourier and difference Fourier synthesis - R factor - structure interpretation - Geometric calculations.
UNIT IV: POWDER METHODS	Fundamentals of powder diffraction - Debye Scherrer method - diffractometer geometries - Use of monochromators and soller silts - sample preparation and data collection - Identification of unknowns - powder diffraction files (ICDD) - Rietveld refinement fundamentals - Profile analysis - Peak shapes - Whole pattern fitting - Structure refinement procedures – Auto-indexing – Structure determination from powder data - new developments. Energy dispersive X-ray analysis – Texture studies - crystallite size determination - Residual stress analysis.
UNIT V: PROTEIN CRYSTALLOGRAPHY	Globular and fibrous proteins, nucleic acids - Primary, secondary, tertiary and quaternary structures - Helical and sheet structures - Ramachandran map and its significance – Crystallization methods for proteins - Factors affecting protein crystallization - Heavy atom derivatives – Methods used to solve protein structures - Anomalous dispersion methods.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.
TEXT BOOKS	1. Elements of X-Ray Crystallography, L.V. Azaroff, Techbooksl, New York, 1992. 2. Protein Crystallography, T.L. Blundell and L. Johnson, Academic Press, New York, 1986. 3. Elements of X-ray Diffraction, B.D. Cullity and S.R. Stock, Pearson, 2014. 4. Introduction to Crystal Growth: Principles and Practice, H.L. Bhat, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2015. 5. Crystal Growth, B.R. Pamplin, Pergamon Press, Oxford, 1975.
REFERENCE BOOKS	1. Crystal Structure Analysis: A Primer, J.P. Glusker and K.N. Trueblood, Oxford University Press, New York, 1994. 2. Structure Determination by X-ray Crystallography, M.F.C. Ladd and R.A. Palmer, Plenum Press, New York, 3rd Edition, 1993. 3. X-ray Structure Determination, A Practical Guide, G.H. Stout and L. Jensen, Macmillan, New York, 1989. 4. An Introduction to X-ray Crystallography, M.M. Woolfson, Cambridge University Press, New York, 1997. 5. Materials Characterization Techniques, Sam Zhang, Lin Ki, Ashok Kumar, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009.
WEB SOURCES	1. https://archive.nptel.ac.in/courses/112/106/112106227/ 2. https://archive.nptel.ac.in/courses/104/108/104108098/ 3. https://www.digimat.in/nptel/courses/video/102107086/L11.html 4. https://onlinecourses.nptel.ac.in/noc19_cy35/previewhttps://onlinecourses.nptel.ac.in/noc19_cy35/preview 5. https://nptel.ac.in/courses/104/104/104104011/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Understand crystal symmetry and reciprocal lattice concept for X-ray diffraction	**K1 K2 K3 K4 K5 K6**
CO2	Gain a working knowledge of X-ray generation, X-ray photography with Laue, oscillation and moving film methods, and space group determination	
CO3	Get an exposure to crystal structure determination using program packages	
CO4	Understand the instrumentation used for powder diffraction, data collection, data interpretation, and structure refinement using Rietveld method	
CO5	Get an insight into the structural aspects of proteins and nucleic acids, crystallization of proteins and methods to solve protein structures	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	2	3
CO2	3	3	3	2	2
CO3	3	3	2	2	2
CO4	3	2	2	2	2
CO5	3	2	2	2	2

ELECTIVE - LIST 1 – 6. MATERIALS SCIENCE

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E06	**MATERIALS SCIENCE**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To gain knowledge on optoelectronic materials ➢ To learn about ceramic processing and advanced ceramics ➢ To understand the processing and applications of polymeric materials ➢ To gain knowledge on the fabrication of composite materials ➢ To learn about shape memory alloys, metallic glasses and nanomaterials

UNITS	Course details
UNIT I: OPTOELECTRONIC MATERIALS	Importance of optical materials – properties: Band gap and lattice matching – optical absorption and emission-, 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.
UNIT 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
UNIT III POLYMERIC MATERIALS	Polymers and copolymers – molecular weight measurement – synthesis: chain growth polymerization – polymerization techniques – glass transition temperature and its measurement – applications: conducting polymers, biopolymers and high temperature polymers.
UNIT 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.
UNIT V: NEW MATERIALS	Shape memory alloys: mechanisms of one-way and two-way shape memory effect, reverse transformation, thermo-elasticity and pseudo-elasticity, examples and applications -bulk metallic glass: criteria for glass formation and stability, examples and mechanical behavior - Nano crystalline materials, single walled and multi walled carbon nanotubes

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Electronic and Optoelectronic Properties of Semiconductor Structures, Jasprit Singh, Cambridge University Press, 2007 2. Fiber-Reinforced Composites, P. K. Mallick, CRC Press, 2008 3. Materials Science and Engineering, V. Raghavan, 4th Edition, Prentice-Hall India, New Delhi, 2003 4. Materials Science, G.K. Narula, K.S. Narula, and V.K. Gupta, Tata McGraw-Hill, 1988 5. Materials Science, M. Arumugam, 3rd revised Edition, Anuratha Agencies, 2002
REFERENCE BOOKS	1. Textbook of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, B. Raj, B. B. Rath, and J. Murday, Springer-Verlag, 2012. 2. Shape Memory and Super Elastic Alloys: Technologies and Applications, K. Yamauchi, I. Ohkata, K. Tsuchiya, and S. Miyazaki (Eds), Woodhead Publishing Limited, 2011. 3. Elements of Materials Science and Engineering, Lawrence H. Van Vlack, 6th Edition, Second ISE reprint, Addison-Wesley, 1998. 4. Solid State Physics – An Introduction to Principles of Materials Science, H. Iabch and H. Luth, 2nd Edition, Springer, 2002. 5. An Introduction to Composite Materials, D. Hull & T. W. Clyne, Cambridge University Press, 2008.
WEB SOURCES	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/courses/113/105/113105025/ 5. https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials_Science)/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Acquire knowledge on optoelectronic materials	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 1 – 7. DIGITAL COMMUNICATION

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E07	**DIGITAL COMMUNICATION**	Elective	4	1	0	3	5	75

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

UNITS	Course Details
UNIT I: **SIGNAL ANALYSIS**	Fourier transforms of gate functions, delta functions at the origin – Two delta function 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.
UNIT II: **INFORMATION THEORY**	Communication system – Measurement of information – Coding – Bandot Code CCITT Code –Hartley Law – Noise in an information Carrying Channel- Effects of noise- Capacity of noise in a channel – Shannon Hartley theorem – Redundancy.
UNIT 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
UNIT IV: **ERROR CONTROL CODING**	Introduction to Linear Block Codes, Hamming Codes, BCH Coding, RS Coding, Convolutional Coding, Coding Grain Viterbi Coding
UNIT V: **SPREAD SPECTRUM SYSTEMS**	Pseudo Noise sequences, generation and Correlation properties, direct sequence spread spectrum systems, frequency HOP Systems, processing gain, anti-jam and multipath performance

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Communication system, B.P. Lathi, Wiley Eastern,1964. 2. Electronic Communication Systems, George Kennedy, Mc Graw Hill, 3rd Edition,2009. 3. Simon Haykin, Communication System, 3rd Edition, John Wiley & Sons,2008. 4. Electronic Communication System, George Kennedy and Davis, Tata McGraw Hill, 4th Edition, 1988 5. "Principles of Communication System", Taub and Schilling, Tata McGraw Hill, Second edition, 1991.
REFERENCE BOOKS	1. Digital Communication, John Proakis, McGraw Hill, Malaysia, 3rd Edition,1995. 2. Digital Communication Techniques, Signal Design and Detection, M. K. Simen, Prentice Hall of India, 1999. 3. Electronics communications, Dennis Roddy and Coolen, Prentice Hall of India IV Edition, 1995. 4. Advanced Electronics communication System, Wave Tomasi, Prentice Hall, Inc, 4th Edition, 1998. 5. Microwave and Radar Engineering, Kulkarni, Umesh Publications, 1988.
WEB SOURCES	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

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Apply the techniques of Fourier transform, convolution and sampling theorems in signal processing	**K1 K2 K3 K4 K5 K6**
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- able to discuss, analyze and compare the different error control coding	
CO5	Apply, discuss and compare the spread spectrum techniques for secure communications	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE LIST 1 – 8. COMMUNICATION ELECTRONICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E08	**COMMUNICATION ELECTRONICS**	Elective	3	1	0	3	4	75

Learning Objectives

- To comprehend the transmission of electromagnetic waves thorough different types of antenna and also to acquire knowledge about the propagation of waves through earth's atmosphere and along the surface of the earth
- To gain knowledge in the generation and propagation of microwaves
- To acquire knowledge about radar systems and its applications and also the working principle of colour television
- To learn the working principle of fiber optics and its use in telecommunication
- To understand the general theory and operation of satellite communication systems

UNITS	Course Details
UNIT I: **ANTENNAS AND WAVE PROPAGATION**	Radiation field and radiation resistance of short dipole antenna-grounded antenna-ungrounded antenna-antenna arrays-broadside and end side arrays-antenna gain-directional high frequency antennas-sky wave-ionosphere- Ecles and Larmor theory- Magnento ionic theory-ground wave propagation
UNIT II: **MICROWAVES**	Microwave generation—multi cavity Klystron-reflex klystron-magnetron travelling wave tubes (TWT) and other microwave tubes-MASER-Gunn diode-wave guides-rectangular wave guides-standing wave indicator and standing wave ratio(SWR)
UNIT III: **RADAR AND TELEVISION**	Elements of a radar system-radar equation-radar performance Factors radar transmitting systems-radar antennas-duplexers-radar receivers and indicators-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
UNIT IV: **OPTICAL FIBER**	Propagation of light in an optical fibre-acceptance angle-numerical aperture-step and graded index fibres-optical fibres as a cylindrical wave guide-wave guide equations-wave guide equations in step index fibres - fibre losses and dispersion-applications
UNIT V: **SATELLITE COMMUNICATION**	Orbital satellites-geostationary satellites-orbital patterns-satellite system link models-satellite system parameters-satellite system link equation link budget-INSAT communication satellites

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Handbook of Electronics, 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, Tata Mc Graw Hill second edition (1991). 4. Microwave and radar engineering, M. Kulkarani, Umesh Publications, 1998. 5. Mono Chrome and colour television, R. R. Ghulathi,1999.
REFERENCE BOOKS	1. Electronic communications – Dennis Roody and Coolen, Prentice Hall of India, IV edition, 1995. 2. Advanced electronics communication systems, Wayne Tomasi, Prentice Hall of India, fourth edition, 1998 3. Electronics communications, Dennis Roddy and Coolen, Prentice Hall of India IV Edition, 1995. 4. "Advanced Electronics communication System" Wayne Tomasi, 4^{th} edition, Prentice Hall of India, 1998 5. Electronic Devices and Circuits, S. Salivahanan, N. Suersh Kumar & A. Vallavaraj, Tata McGraw-Hill Publishing Company Limited, New Delhi, Second Edition, 2009.
WEB SOURCES	1. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/ 2. https://www.polytechnichub.com/difference-analog-instruments-digital-instruments/ 3. http://nptel.iitm.ac.in/ 4. http://web.ewu.edu/ 5. http://nptel.iitm.ac.in/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Discuss and compare the propagation of electromagnetic waves through sky and on earth's surface Evaluate the energy and power radiated by the different types of antenna	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Compare and differentiate the methods of generation of microwaves analyze the propagation of microwaves through wave guides- discuss and compare the different methods of generation of microwaves	
CO3	Classify and compare the working of different radar systems- apply the principle of radar in detecting locating, tracking, and recognizing objects of various kinds at considerable distances – discuss the importance of radar in military- elaborate and compare the working of different picture tube	
CO4	Classify, discuss and compare the different types of optical fiber and also to justify the need of it-discover the use of optical fiber as wave guide	
CO5	Explain the importance of satellite communication in our daily life-distinguish between orbital and geostationary satellites elaborate the linking of satellites with ground station on the earth	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (CO) for each course with program outcomes (PO) in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1).

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 2 – 9. MICROPROCESSOR 8085 AND MICROCONTROLLER 8051

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E09	**MICROPROCESSOR 8085 AND MICROCONTROLLER 8051**	Elective	4	1	0	3	5	75

Learning Objectives

- To provide an understanding of the architecture and functioning of microprocessor 8085A and to the methods of interfacing I/O devices and memory to microprocessor
- To introduce 8085A programming and applications and the architecture and instruction sets of microcontrollers 8051
- To write assembly language programs of Microprocessor for various applications.
- To know the architecture aspects of Microcontrollers.
- To know the importance of different peripheral device and their interfacing to Microcontrollers.

UNITS	Course Details
UNIT I: 8085 PROGRAMMING, PERIPHERAL DEVICES AND THEIR INTERFACING	Instruction set - Addressing modes - Programming techniques - Memory mapped I/O scheme- I/O mapped I/O scheme - Memory and I/O interfacing- Data transfer schemes - Interrupts of 8085 - Programmable peripheral interface (PPI) - Control group and control word- Programmable DMA controller - Programmable interrupt controller – Programmable communication interface - Programmable counter /interval timer.
UNIT II: 8085 INTERFACING APPLICATIONS	Seven segment display interface - Interfacing of Digital to Analog converter and Analog to Digital converter - Stepper motor interface - Measurement of electrical quantities –Voltage and current) Measurement of physical quantities (Temperature an strain).
UNIT III: 8051 MICROCONTROLLER HARDWARE	Introduction – Features of 8051 – 8051 Microcontroller Hardware: Pin-out 8051, Central Processing Unit (CPU), internal RAM, Internal ROM, Register set of 8051 – Memory organization of 8051 – Input/ Output pins, Ports and Circuits – External data memory and program memory: External program memory, External data memory.
UNIT IV: 8051 INSTRUCTIONS SET AND ASSEMBLY LANGUAGE	Addressing modes – Data moving (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

PROGRAMMING	operations, Rotate and swap operations – Arithmetic instructions: Flags, Incrementing and decrementing, Addition, Subtraction, Multiplication and division, Decimal arithmetic – Jump and CALL instructions: Jump and Call program range, Jump, Call and subroutines – Programming.
UNIT V: INTERRUPT PROGRAMMING AND INTERFACING TO EXTERNAL WORLD	8051 Interrupts – Interrupt vector table – Enabling and disabling an interrupt – Timer interrupts and programming – Programming external hardware interrupts – Serial communication interrupts and programming – Interrupt priority in the 8051 : Nested interrupts , Software triggering of interrupt. LED Interface Seven segment display interface- Interfacing of Digital to Analog converter and Analog to Digital converter - Stepper motor interface - Measurement of electrical quantities – Voltage and current) Measurement of physical quantities(Temperature an strain).
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Microprocessors & Microcontrollers, A. NagoorKani, RBA Publications 2009 2. Microprocessors, A. P. Godse and D. A. Godse, Technical Publications, Pune 2009. 3. Microprocessor Architecture, Programming and Applications with 8085, Ramesh Gaonkar Penram International Publishing 2013. 4. Fundamentals of Microprocessors & Microcontrollers, B. Ram, DhanpatRai publications New Delhi 2016. 5. Fundamentals of Microprocessor-8085", V. Vijayendran, S.Visvanathan Pvt, Ltd. 3rd Edition, 2005.
REFERENCE BOOKS	1. Microprocessors and Interfacing programming and Hardware, Douglas V. Hall, Tata Mc Graw Hill Publications 2008 2. Muhammad Ali Mazidi, Janice GillispieMazidi, Rolin D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson Education 2008. 3. The Intel Microprocessors 8086/8088, 80186, 80286, 80386 and 80486, Barry B. Brey, Prentice- Hall of India, New Delhi, 3rd Edition 1995. 4. "The 8086/8088 Family-Design, Programming and Interfacing, Software, Hardware and Applications", J. Uffrenbeck, Prentice-Hall of India, New Delhi 1985. 5. "The 8086/8088 Microprocessors: Programming, Interfacing, Software, Hardware and Applications", W. A. Tribel, Avtar Singh, Prentice-Hall of India, New Delhi,2006.

WEB SOURCES	1. https://www.tutorialspoint.com/microprocessor/microprocessor_8085_architecture.html 2. http://www.electronicsengineering.nbcafe.in/peripheral-mapped-io-interfacing/ 3. https://www.geeksforgeeks.org/programmable-peripheral-interface-8255/ 4. http://www.circuitstoday.com/8051-microcontroller 5. https://www.elprocus.com/8051-assembly-language-programming/

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gain knowledge of architecture and working of 8085 microprocessors.	**K1** **K2** **K3** **K4** **K5** **K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 2 – 10. PLASMA PHYSICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E10	**PLASMA PHYSICS**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To study the fundamental concepts of Plasma ➢ To learn the behavior in magnetic field ➢ To understand the model plasma phenomena in the universe. ➢ To explore the plasma universe by means of in-site and ground-based observations. ➢ To explore the physical processes which occur in the space environment

UNITS	Course Details
UNIT I: FUNDAMENTAL CONCEPTS 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.
UNIT 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 particle inhomogeneous 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.
UNIT III: PLASMA OSCILLATIONS AND 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.
UNIT IV: PLASMA DIAGNOSTICS TECHNIQUES	Single probe method - Double probe method - Use of probe technique for measurement 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.
UNIT V: APPLICATIONS OF PLASMA PHYSICS	Magneto hydrodynamic Generator - Basic theory - Principle of Working-Fuel in MHD Generator - Generation of Microwaves Utilizing High Density Plasma - Plasma Diode.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Introduction to Electrodynamics – David J. Griffiths, 4th Edition, Pearson, 2012. 2. Electromagnetic Theory and Electrodynamics –Sathya Prakash, Kedar Nath Ram Nath and Co, 2017. 3. Electromagnetics - B.B Laud, Wiley Eastern Company, 2000. 4. Fundamentals of Electromagnetic -Wazed Miah, Tata Mc Graw Hill, 1980. 5. Basic Electromagnetics with Application - Narayana rao, (EEE) Prentice Hall, 1997.
REFERENCE BOOKS	1. Fundamentals of Electromagnetic Theory – John R.Reitz, Frederick J Milford and Robert W.Christy, 3rd edition, Narosa Publishing House, New Delhi, 1998. 2. Classical Electrodynamics – J.D. Jackson, II Edition, Wiley Eastern Limited, 1993. 3. Electromagnetic Fields and Waves – P. Lorrain and D.Corson, 1987. 4. Electromagnetics, B.B Laud, Wiley Eastern Company, 2000.
WEB SOURCES	1. http://www.plasmas.org/resources.htm 2. http://www.ipr.res.in/library/onlineres/ppresource.html 3. https://www.springer.com/journal/11452 4. https://www.nature.com/subjects/plasma-physics 5. https://libguides.princeton.edu/c.php?g=84106&p=542104

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the collision, cross section of charged particles and to able to correlate the magnetic effect of ion and electrons in plasma state.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Understand the plasma and learn the magneto-hydrodynamics concepts applied to plasma.	
CO3	Explore the oscillations and waves of charged particles and thereby apply the Maxwell's equation to quantitative analysis of plasma.	
CO4	Analyze the different principle and techniques to diagnostics of plasma.	
CO5	Learn the possible applications of plasma by incorporating various electrical and electronic instruments.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	2	2
CO2	3	3	2	2	2
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

ELECTIVE - LIST 2 – 11. BIO PHYSICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E11	BIOPHYSICS	Elective	3	1	0	3	4	75

Learning Objectives

- To understand the physical principles involved in cell function maintenance.
- To understand the fundamentals of macromolecular structures involved in propagation of life.
- To understand the biophysical function of membrane and neuron.
- To understand various kinds of radiation and their effects on living system and to know the hazards posed by such radiations and the required precautions.
- To understand the physical principles behind the various techniques available for interrogating biological macromolecules.

UNITS	Course Details
UNIT I: CELLULAR BIOPHYSICS	Architecture and Life Cycle of cells – Organelles of Prokaryotic and Eukaryotic cell – Cell size and shape – Fine structure of Prokaryotic and Eukaryotic cell organization – Compartment & assemblies membrane system – Extracellular matrix - Molecular mechanisms of Vesicular traffic - Electrical activities of cardiac and neuronal cells.
UNIT II: MOLECULAR BIOPHYSICS	Macromolecular structure: Protein structure – amino acids, peptide bonds, primary, secondary, tertiary and quaternary structures of proteins Nucleic acid structure: nucleosides and nucleotides, RNA structure, DNA structure and conformation. Special Bio-macromolecules: Metalloproteins, nucleoproteins, ribozymes, chaperons and prions.
UNIT III: MEMBRANE AND NEURO BIOPHYISCS	Models membranes - Biological membranes and dynamics – Membrane Capacitors – Transport across cell and organelle membranes – Ion channels. Nervous system: Organization of the nervous system –Membrane potential – Origins of membrane potential - Electrochemical potentials – Nernst equation – Goldman equation.
UNIT IV: RADIATION BIO PHYSICS	X-Ray: Effects on bio-macromolecules – Gamma Radiation: Molecular effects of gamma radiation, Radiation effects on nucleic acids and membranes, Effects on cell and organelles – UV radiation: Effects on bio-macromolecules and proteins – Radiation hazards and protection – use of radiations in cancer.
UNIT V: PHYSICAL METHODS IN BIOLOGY	Spectroscopy: UV-Visible absorption spectrophotometry – Optical Rotatory Dispersion (ORD) – Structure Determination: X-ray Crystallography, Electron spin resonance (ESR) and biological applications. Chromatography: Thin layer chromatography (TLC), Gas liquid chromatography (GLC) – Centrifugation: Differential centrifugation, density gradient centrifugation. Electrophoresis: Gel electrophoresis, polyacrylamide gel electrophoresis.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. The cell: A molecular approach-Geoffrey M. Cooper, ASM Press, 2013. 2. Biophysics- VasanthaPattabhi, N. Gautham, Narosa Publishing, 2009 3. Biophysics- P. S. Mishra VK Enterprises, 2010. 4. Biophysics- M. A Subramanian, MJP Publishers, 2005. 5. Bioinstrumentation-L. Veerakumari, MJP Publishers, 2006.
REFERENCE BOOKS	1. Chemical Biophysics- Daniel A.Beard,Cambridge University Press, 2008. 2. Essential cell biology -Bruce Albert et al.,Garland Science. 3. Biophysics- W. Hoppe, W. Lohmann, H. Markl and H. Ziegler. Springer Verlag, Berlin,1983. 4. Membrane Biophysics - Mohammad Ashrafuzzaman, Jack A. Tuszynski, Springer science & business media. 5. Biological spectroscopy-Iain D. Campbell, Raymond A. Dwek
WEB SOURCES	1. General Bio: http://www.biology.arizona.edu/DEFAULT.html 2. Spectroscopy: http://www.cis.rit.edu/htbooks/nmr/inside.htm 3. Electrophoresis:http://learn.genetics.utah.edu/content/labs/gel/ 4. Online biophysics programs: http://mw.concord.org/modeler/ 5. https://blanco.biomol.uci.edu/WWWResources.html

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the structural organization and function of living cells and should able to apply the cell signaling mechanism and its electrical activities.	**K1 K2 K3 K4 K5 K6**
CO2	Comprehension of the role of biomolecular conformation to function.	
CO3	Conceptual understanding of the function of biological membranes and also to understand the functioning of nervous system.	
CO4	To know the effects of various radiations on living systems and how to prevent ill effects of radiations.	
CO5	Analyze and interpret data from various techniques viz., spectroscopy, crystallography, chromatography etc.,	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	3	3	3
CO4	3	3	3	2	2
CO5	3	3	3	3	2

ELECTIVE - LIST 2 – 12. NON-LINEAR DYNAMICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E12	**NONLINEAR DYNAMICS**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To edifice the students about the analytical and numerical techniques of nonlinear dynamics.
➢ To make the students understand the concepts of various coherent structures.
➢ To train the students on bifurcations and onset of chaos.
➢ To educate the students about the theory of chaos and its characterization.
➢ To make the students aware of the applications of solitons, chaos and fractals.

UNITS	Course Details
UNIT - 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
UNIT - 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, Painleve analysis - Perturbation methods- Solitons in Optical fibres - Applications.
UNIT - III: BIFURCATIONS AND ONSET OF CHAOS	One dimensional flows – Two dimensional flows – Phase plane – Limit cycles – Simple bifurcations – Discrete Dynamical system – Strange attractors – Routes to chaos.
UNIT - IV FRACTALS AND STRANGE ATTRACTORS	Fractals : examples, similarity dimension and box dimension; Rayleigh-Benard convection : basic equations, Boussinesq approximation; Lorenz map : Stability of fixed points and appearance of strange attractors; Baker's map; Henon map : relation with periodically kicked rotator, stability of fixed points and appearance of strange attractors.
UNIT - 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.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.

TEXT BOOKS	1. Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003. 2. Solitons in Optical Communications, A. Hasegawa and Y. Kodama, Oxford Press, 1995. 3. Nonlinear Systems, P. G. Drazin, Cambridge University Press, 2012. ISBN: 9781139172455. 4. Introduction to Applied Nonlinear Dynamical Systems and Chaos, S. Wiggins, Springer, 2003. ISBN: 9780387001777. 5. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, Strogatz, Steven H. Westview Press, 2014. ISBN: 9780813349107.
REFERENCE BOOKS	1. Solitons: An Introduction, G. Drazin and R. S. Johnson, Cambridge University Press, 1989. 2. Chaos in Nonlinear Oscillators, M. Lakshmanan and K. Murali, World Scientific, 1989. 3. Nonlinear Dynamics and Chaos, S. Strogatz, Addison Wesley, 1995. 4. Chaos, Hao Bai-Lin, World Scientidic, Singapore, 1984. 5. Mathematical Methods for Scientists & Engineers, P.B. Kahn, Wiley, NY, 1990.
WEB SOURCES	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

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Gain knowledge about the available analytical and numerical methods to solve various nonlinear systems.	**K1** **K2** **K3** **K4** **K5** **K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	2	3
CO2	3	2	2	2	3
CO3	2	2	2	2	2
CO4	2	2	2	2	2
CO5	1	2	2	2	1

ELECTIVE - LIST – 2. 13. QUANTUM FIELD THEORY

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E13	**QUANTUM FIELD THEORY**	Elective	3	1	0	3	4	75

Learning Objectives

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

UNITS	Course Details
UNIT 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.
UNIT 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 eigen states of the Hamiltonian, vacuum expectation values, propagators, spin and statistics of the KG quantum.
UNIT 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.
UNIT 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 propagator of the photon.
UNIT 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.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. J. D. Bjorken and S. D. Drell, Relativistic Quantum Fields, McGraw-Hill Book Company, 1965. 2. An Introduction to Quantum Field Theory, M.E. Peskin and D. V. Schroeder, Taylor and Francis, 2018. 3. Quantum Field theory: From Operators to Path Integrals, Kerson Huang, Wiley, 2nd Edition, 2008. 4. Quantum Field Theory, Mark Srednicki, 2006. 5. Quantum Field Theory, Claude Itzykson and Jean Bernard Zuber, Dover, 2006.
REFERENCE BOOKS	1. Quantum Electrodynamics,V. B. Berestetskii, E. M. Lifshitz and L. P. Pitaevskii, Elseveir, 1982. 2. Introduction to Theory of Quantized Fields, N. N. Bogoliubov and D. V. Shirkov, 1959. 3. Quantum Field Theory, L. H. Ryder, Cambridge University Press, 2nd Edition, 1996. 4. Quantum Field Theory, L. S. Brown, Cambridge University Press, 1992. 5. Quantum Field Theory: A Modern Introduction, M. Kaku, Oxford University Press, 1993
WEB SOURCES	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/

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the interconnection of Quantum Mechanics and Special Relativity	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	2
CO2	3	3	2	3	3
CO3	3	3	2	3	2
CO4	3	3	2	3	3
CO5	3	3	2	3	3

ELECTIVE - LIST – 2. 14 - GENERAL RELATIVITY AND COSMOLOGY

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E14	**GENERAL RELATIVITY AND COSMOLOGY**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To give an introduction to students in the areas of general relativity and cosmology
➢ To understanding of the underlying theoretical aspects of general relativity and cosmology
➢ To gain knowledge on space time curvature
➢ To equipped to take up research in cosmology
➢ To confidently solve problems using mathematical skills

UNITS	Course Details
UNIT 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
UNIT I: 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
UNIT III: GENERAL RELATIVITY	The space time interval - the metric - Lorentz transformations - space-time diagrams - world-lines - proper time - energy-momentum vector - energy-momentum 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
UNIT 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
UNIT 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

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	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 Plebanski and AndrzejKrasinski, 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, 1992. 2. J. V. Narlikar, Introduction to Cosmology, Jones & Bartlett, 1983. 3. Steven Weinberg, Gravitation and Cosmology, New York, Wiley, 1972. 4. Jerzy Plebanski and AndrzejKrasinski, An Introduction to General Relativity and Cosmology, Cambridge University Press, 2006. 5. R Adler, M Bazin & M Schiffer, Introduction to General Relativity, McGraw Hill Book company, 1975.
WEB SOURCES	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-you-can-learn-applied-mathematics/relativity-and-cosmology

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Skillfully handle tensors	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	2
CO2	3	3	2	3	3
CO3	3	3	2	3	2
CO4	3	3	2	3	3
CO5	3	3	2	3	3

ELECTIVE - LIST 2 – 15. ADVANCED OPTICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E15	**ADVANCED OPTICS**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To know the concepts behind polarization and could pursue research work on application aspects of laser ➢ To impart an extensive understanding of fiber and non-linear optics ➢ To study the working of different types of LASERS ➢ To differentiate first and second harmonic generation ➢ Learn the principles of magneto-optic and electro-optic effects and its applications

UNITS	Course Details
UNIT 1: 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
UNIT 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 – Nd:YAG laser – gas lasers – He-Ne laser – CO_2 laser – Semiconductor laser
UNIT 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 – Parabolic-index fibers – Fiber-optic sensors: precision displacement sensor – Precision vibration sensor
UNIT 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
UNIT V: MAGNETO-OPTICS AND ELECTRO-OPTICS	Magneto-optical effects – Zeeman effect – Inverse Zeeman effect – Faraday effect — Kerr magneto-optic effect – Electro-optical effects – Stark effect – Inverse stark effect – Electric double refraction – Kerr electro-optic effect – Pockels electro-optic effect
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Lasers and Non – Linear Optics, B. B. Laud, 3rd Edition, New Age International (P) Ltd., 2017. 2. Optics, Ajoy Ghatak, 6th Edition, McGraw – Hill Education Pvt. Ltd, 2017. 3. Laser Fundamentals, William T. Silfvast, Cambridge University Press, New York, 1996. 4. Physics of Light and Optics, Justin Peatross, Michael Ware, Brigham Young University, 2011. 5. B. E. A Saleh, and M.C. Teich, Fundamentals of Photonics, Wiley India Pvt Ltd, 2012.
REFERENCE BOOKS	1. Fundamentals of Optics, F. S. Jenkins and H. E. White, (4th Edition), McGraw – Hill International Edition, 1981. 2. Optics, Light and Lasers, Dieter Meschede, Wiley – VCH, Varley GmbH, 2004. 3. Optical Physics, Lipson, S. G. Lipson and H. Lipson, 4th Edition, Cambridge University Press, New Delhi, 2011. 4. Light and Matter, Y. B. Band, , Wiley and Sons, 2006. 5. Modern Optics, R. Guenther, Wiley and Sons, 1990.
WEB SOURCES	1. https://www.youtube.com/watch?v=WgzynezPiyc 2. https://www.youtube.com/watch?v=ShQWwobpW60 3. https://www.ukessays.com/essays/physics/fiber–optics–and–it-applications.php 4. https://www.youtube.com/watch?v=0kEvr4DKGRI 5. http://optics.byu.edu/textbook.aspx

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Discuss the transverse character of light waves and different polarization phenomenon	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 2 – 16. ADVANCED MATHEMATICAL PHYSICS								
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
23UPPHY1E16	**ADVANCED MATHEMATICAL PHYSICS**	Elective	3	1	0	3	4	75

Learning Objectives

- To develop knowledge in group theory, special theory of relativity and tensor and its applications.
- To develop expertise in mathematical techniques required in physics.
- To enhance problem solving skills in group theory, special theory of relativity and tensor.
- To enable students to formulate, interpret and draw inferences from mathematical solutions
- To develop skills to apply group theory and tensors to peruse research

UNITS	Course Details
UNIT 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.
UNIT 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.
UNIT 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.

UNIT IV: TENSORS	Cartesian vectors and tensors illustration with moment of inertia, conductivity, dielectric tensors. Four vector in special relativitity, 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.
UNIT 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.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Group Theory for Physicists, A. W. Joshi, New Age International Publishers, Fifth edition, 2018 2. Unitary Symmetry and Elementary Particles, D. B. Lichtenberg, New York : Academic Press, 1978. 3. Mathematical Physics, E. Butkov, Addison-Wesley Publishing Company, 1968. 4. General Relativity & Cosmology, J. V. Narlikar, Macmillan, 1979. 5. Mathematical Physics, R. Geroch, The University of Chicago press, 1985.
REFERENCE BOOKS	1. Group Theory, M. Hamermesh, Dover Publications Inc.; Reprint edition, 2003 2. Elementary Theory of Angular Momentum, M. E. Rose, Dover Publications Inc., New edition, 2003. 3. Georgi : Lie Groups for Physicists, 2019 edition. 4. Tensors, Relativity & Cosmology, E. A. Lord, Tata McGraw-Hill, 1976. 5. A course in modern mathematical physics: Groups, Hilbert spaces and differential geometry, P. Szekeres, Cambridge University Press, 2004
WEB SOURCES	1. https://vdoc.pub/documents/unitary-symmetry-and-elementary-particles-c4qsfejthkc0 2. https://physics.iith.ac.in/HEP_Physics/slides/poplawskitalk.pdf 3. https://www.hindawi.com/journals/amp/ 4. https://projecteuclid.org/journals/advances-in-theoretical-and-mathematical-physics 5. https://www.springer.com/journal/11232

COURSE OUTCOMES:

At the end of the course, the student will be able

CO1	Gain knowledge of both discrete and continuous groups	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Apply various important theorems in group theory	
CO3	Construct group multiplication table, character table relevant to important branches of physics.	
CO4	Equip to solve problems in tensors	
CO5	Develop skills to apply group theory and tensors to peruse research	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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	1	1

ELECTIVE - LIST 3 - 17. ADVANCED SPECTROSCOPY

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E17	**ADVANCED SPECTROSCOPY**	Elective	3	1	0	3	4	75

Learning Objectives

- Helps students understand and appreciate spectroscopy as a sufficiently broad field in which many sub disciplines exist.
- To understand the recent advances in laser technology
- Make them appreciate each of these specific techniques with numerous implementations.
- To realize the progress in this field that is rapid, resulting in improved instrument capabilities and an ever-widening range of applications.
- To apply group theory in spectroscopy to shed light on molecular symmetry and determine important physical parameters.

UNITS	Course Details
UNIT I: MOLECULAR SPECTROSCOPY AND GROUP THEORY	Group axioms –subgroup, simple group, Abelian group, cyclic group, order of a group, class- Lagrange's theorem statement and proof - Symmetry operations and symmetry elements - Application: construction of group multiplication table (not character table) for groups of order 2, 3, cyclic group of order 4, noncyclic group of order 4 – reducible and irreducible representations- Unitary representations – Schur's lemmas – Great orthogonality theorem - point group -Simple applications : Symmetry operations of water and ammonia- Construction of character table for C_{2v} (water) and C_{3v} (ammonia) molecules
UNIT II: LASER SPECTROSCOPY	Lasers as Spectroscopy Light sources – Special Characteristics of Laser emission- ultra short pulses- laser cooling -Single and multi-mode lasers- Laser tenability- Fluorescence spectroscopy with lasers- Laser Raman Spectroscopy – Non-linear Spectroscopy – Applications of Laser Spectroscopy in medical fields, materials science research
UNIT III: MOSSBAUER SPECTROSCOPY	Basic idea of Mossbauer spectroscopy - Principle- Mossbauer effect- Recoilless emission and absorption- Chemical shift -Effect of electric and magnetic fields – hyperfine interactions- instrumentation- Applications: understanding molecular and electronic structures
UNIT IV: XRAY PHOTOELECTRON SPECTROSCOPY	Principle – XPS spectra and its interpretation- ECSA-EDAX- other forms of XPS – chemical shift - Applications : - stoichiometric analysis- electronic structure- XPES techniques used in astronomy, glass industries, paints and in biological research
UNIT V: MOLECULAR MODELLING	Determination of force constants- force field from spectroscopic data- normal coordinate analysis of a simple molecule (H_2O) – analyzing thermodynamic functions, partition functions, enthalpy, specific heat and related parameters from spectroscopic data- molecular modelling using data from various spectroscopic studies

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	**1.** Organic Spectroscopy, William Kemp, MacMillan, Indian Edition, 2nd Edition, 2019. 2. Fundamentals of Molecular Spectroscopy, C N Banwell and McCash, Tata McGraw–Hill, New Delhi, 4th Edition, 1994. 3. Vibrational Spectroscopy and Applications, D.N. Satyanarayana, New Age International Publication, 2001. 4. Spectroscopy, B.K. Sharma , Goel Publishing House Meerut, 2015 5. Basic Atomic and Molecular Spectroscopy, J M Hollas, Royal Society of Chemistry, RSC, Cambridge, 2002.
REFERENCE BOOKS	1. Molecular Spectroscopy, J L McHale, Pearson Education India, New Delhi, 2008. 2. Basic Atomic and Molecular Spectroscopy, J M Hollas, Royal Society of Chemistry, RSC, Cambridge, 2002. 3. Spectroscopy Vol. I, B. P. Straughan and S. Walker, Chapman and Hall, New York, 1976. 4. Introductory Quantum Chemistry, K. Chandra, Tata McGraw Hill, New Delhi, 1989. 5. Laser Spectroscopy: Basic concepts and Instrumentation, W. Demtroder, Springer Link
WEB SOURCES	1. https://www.youtube.com/watch?v=0iQhirTf2PI 2. https://www.coursera.org/lecture/spectroscopy/introduction-3N5D5 3. https://www.coursera.org/lecture/spectroscopy/infrared-spectroscopy-8jEee 4. https://onlinecourses.nptel.ac.in/noc20_cy08/preview 5. https://www.coursera.org/lecture/spectroscopy/nmr-spectroscopy-introduction-XCWRu

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Comprehend set of operations associated with symmetry elements of a molecule, apply mathematical theory while working with symmetry operations.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Align with the recent advances in semiconductor laser technology combined sensitive spectroscopic detection techniques.	
CO3	Understand principle behind Mossbauer spectroscopy and apply the concepts of isomer shift and quadrupole splitting to analyse molecules.	
CO4	Assimilate this XPES quantitative technique and the instrumentation associated with this, as applied in understanding surface of materials.	
CO5	Employ IR and Raman spectroscopic data along with other data for structural and thermodynamic functions investigation of molecules.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	2	3
CO2	2	2	2	3	3
CO3	2	2	3	3	3
CO4	3	2	3	3	2
CO5	3	2	3	3	3

ELECTIVE - LIST 3 – 18. CHARACTERIZATON OF MATERIALS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E18	**CHARACTERIZATON OF MATERIALS**	Elective	3	1	0	3	4	75

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

UNITS	Course Details
UNIT 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.
UNIT 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.
UNIT 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.
UNIT 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.
UNIT V X-RAY AND SPECTROSCOPIC METHODS	Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, NQR, XPS, AES and SIMS-proton induced X-ray Emission spectroscopy (PIXE) –Rutherford Back Scattering (RBS) analysis-application - Powder diffraction - Powder diffractometer -interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.

Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Growth and Characterization of semiconductors- R. A. Stradling and P. C. Klipstain, Adam Hilger, Bristol, 1990. 2. Electron microscopy and microanalysis of crystalline materials - J. A. Belk, Applied Science Publishers, London, 1979. 3. Electron and Ion microscopy and Microanalysis principles and Applications- Lawrence E. Murr, Marcel Dekker Inc., New York, 1991 4. Analytical Chemistry- D. Kealey and P. J. Haines, Viva Books Private Limited, New Delhi, 2002. 5. Materials Characterization Techniques- Li, Lin, Ashok Kumar, Sam Zhang; CRC Press, 2008.
REFERENCE BOOKS	1. Elements of X-Ray Diffraction – B.D. Cullity and R.S. Stock, Prentice-Hall, 2001. 2. Fundamentals of Light Microscopy and Electronic Imaging- Murphy B. Douglas, Wiley-Liss, Inc. USA, 2001. 3. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series)- A.K. Tyagi, Roy, Mainak, S.K. Kulshreshtha and S. Banerjee, Volume 49 – 51, 2009. 4. Thermal Analysis- W.W. Wendlandt, John Wiley & Sons, 1986. 5. Characterization of Materials- J.B. Wachtman,Z.H. Kalman, Butterworth Heinemann, 1993.
WEB SOURCES	1. http://www.digimat.in/nptel/courses/video/113106034/L11.html 2. https://nptel.ac.in/courses/104106122 3. https://nptel.ac.in/courses/118104008 4. https://www.sciencedirect.com/journal/materials-characterization 5. https://www.vssut.ac.in/lecture_notes/lecture1429901637.pdf

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Describe the TGA, DTA, DSC and TMA thermal analysis techniques and make interpretation of the results.	**K1** **K2** **K3** **K4** **K5** **K6**
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.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 3 – 19. MEDICAL PHYSICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E19	**MEDICAL PHYSICS**	Elective	3	1	0	3	4	75

Learning Objectives

- To understand the major applications of Physics to Medicine
- To study the aid of different medical devices such as X-ray machines, gamma camera, accelerator and nuclear magnetic resonance.
- To outline the principles of Physics of different medical radiation devices and their modern advances, especially in medical radiation.
- To introduce the ideas of Radiography.
- To form a good base for further studies like research.

UNITS	Course Details
UNIT I: X-RAYS AND TRANSDUCERS	Electromagnetic Spectrum – Production of X-Rays – X-Ray Spectrum –Bremsstrahlung – Characteristic X-Ray – X-Ray Tubes – Coolidge Tube – X-Ray Tube Design – Thermistors – photo electric transducers – Photo voltaic cells – photo emissive cells –Photoconductive cells– piezoelectric transducer
UNIT II: BLOOD PRESSURE MEASUREMENTS	Introduction –□sphygmomanometer – Measurement of heart rate – basic principles of electrocardiogram (ECG) –Basic principles of electro-neurography (ENG) – Basic principles of magnetic resonance imaging (MRI).
UNIT III: RADIATION PHYSICS	Radiation Units – Exposure – Absorbed Dose – Rad to Gray – Kera Relative Biological Effectiveness –Effective Dose – Sievert (Sv) – Inverse Square Law – Interaction of radiation with Matter – Linear Attenuation Coefficient – Radiation Detectors –Thimble Chamber – Condenser Chambers – Geiger Counter – Scintillation Counter
UNIT IV: MEDICAL IMAGING PHYSICS	Radiological Imaging – Radiography – Filters – Grids – Cassette – X-Ray Film – Film processing – Fluoroscopy – Computed Tomography Scanner – Principal Function – Display – Mammography – Ultrasound Imaging – Magnetic Resonance Imaging – Thyroid Uptake System – Gamma Camera (Only Principle, Function and display)
UNIT V: RADIATION PROTECTION	Principles of Radiation Protection – Protective Materials – Radiation Effects – Somatic – Genetic Stochastic and Deterministic Effect – Personal Monitoring Devices – TLD Film Badge – Pocket Dosimeter
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Basic Radiological Physics, Dr. K. Thayalan , Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi, 2003.

	2. Christensen's Physics of Diagnostic Radiology, Curry, Dowdey and Murry, Lippincot Williams and Wilkins, 1990. 3. Physics of Radiation Therapy, FM Khan, William and Wilkins, 3rd edition, 2003. 4. An Introduction to Biomedical Instrumentation, D. J. Dewhurst, Elsevier Science, 1st edition, 2014. 5. Hand Book of Biomedical Instrumentations, R.S. Khandpur, TMG, New Delhi, 1st edition, 2005.
REFERENCE BOOKS	1. An Introduction to Medical Physics, Muhammad Maqbool, Springer International Publishing, 1st edition, 2017. 2. Basics of Medical Physics, Daniel Jirák, FrantišekVítek, Charles University, Karolinum Press, 1st edition, 2018. 3. Comprehensive Biomedical Physics, Volume 1, Anders Brahme, Elsevier Science, 1st edition, 2014. 4. Bio-Medical Electronics and Instrumentation, K. Venkata Ram, Galgotia Publications, New Delhi, 1st edition, 2001. 5. Medical Physics, John R. Cameron and James G. Skofronick, John Wiley Interscience Publication, Canada, 2nd edition, 2009.
WEB SOURCES	1. https:nptel.ac.in/courses/108/103/108103157/ 2. https://www.studocu.com/en/course/university-of-technology-sydney/medical-devices-and-diagnostics/225692 3. https://www.technicalsymposium.com/alllecturenotes_biomed.html 4. https://lecturenotes.in/notes/17929-note-for-biomedical-instrumentation-bi-by-deepraj-adhikary/78 5. https://www.modulight.com/applications-medical/

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Learn the fundamentals, production and applications of X-rays.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Understand the basics of blood pressure measurements. Learn about sphygmomanometer, EGC, ENG and basic principles of MRI.	
CO3	Apply knowledge on Radiation Physics	
CO4	Analyze Radiological imaging and filters	
CO5	Assess the principles of radiation protection	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	1	1
CO2	3	3	3	2	1
CO3	3	3	3	2	1
CO4	3	3	3	2	1
CO5	3	3	3	1	1

ELECTIVE - LIST 3 – 20. SOLID WASTE MANAGEMENT

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E20	**SOLID WASTE MANAGEMENT**	Elective	3	1	0	3	4	75

Learning Objectives
➢ To gain basic knowledge in solid waste management procedures ➢ To gain industry exposure and be equipped to take up a job. ➢ To harness entrepreneurial skills. ➢ To analyze the status of solid waste management in the nearby areas. ➢ To sensitize the importance of healthy practices in waste managements.

UNITS	Course Details
UNIT I: SOLID WASTE MANAGEMENT	Introduction - Definition of solid waste - Types – Hazardous Waste: Resource conservation and Renewal act – Hazardous Waste: Municipal Solid waste and non-municipal solid waste.
UNIT II: SOLID WASTE CHARACTERISTICS	Solid Waste Characteristics: Physical and chemical characteristics - SWM hierarchy - factors affecting SW generation
UNIT III: TOOLS AND EQUIPMENT	Tools and equipment - Transportation - Disposal techniques - Composting and land filling technique
UNIT IV: ECONOMIC DEVELOPMENT	SWM for economic development and environmental protection Linking SWM and climate change and marine litter.
UNIT V: INDUSTRIAL VISIT	SWM Industrial visit – data collection and analysis - presentation
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Handbook of Solid Waste Management, George Tchobanoglous, McGraw Hill, 2nd Edition, 2002. 2. Prospects and Perspectives of Solid Waste Management, B. B. Hosetti, New Age International (P) Ltd, 2006. 3. Solid and Hazardous Waste Management, M.N Rao and Razia Sultana, BS Publications, 2nd Edition, 2020,

	4. Integrated Solid Waste Management Engineering Principles and Management Issues, George Tchobanoglous, Hilary Theisen, S. A. Vigil , McGraw Hill, 2014. 5. Solid and Liquid Waste Management, Vasudevan Rajaram, PHI learning private limited, 2016.
REFERENCE BOOKS	1. Municipal Solid Waste Management, Christian Ludwig, Samuel Stucki, Stefanie Hellweg, Springer Berlin Heisenberg, 2012 2. Solid Waste Management Bhide A. D Indian National Scientific Documentation Centre, New Delhi, 1983. 3. Environmental Studies, D.L. Manjunath, Pearson Education Publication, New Delhi, 2006. 4. Solid Waste Management, K. Sasikumar, PHI learning, New Delhi, 2009.
WEB SOURCES	1. https://www.meripustak.com/Integrated-Solid-Waste-Management-Engineering-Principles-And-Management-Issues-125648 2. https://testbook.com/learn/environmental-engineering-solid-waste-management/ 3. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsA-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJ_jxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 4. https://images.app.goo.gl/tYiW2gUPfS2cxdD28 5. https://amzn.eu/d/5VUSTDI

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Gained knowledge in solid waste management	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	3	3	3	2
CO2	2	3	3	2	2
CO3	2	3	2	2	2
CO4	3	2	2	2	2
CO5	2	3	3	2	2

ELECTIVE - LIST 3 – 21. SEWAGE AND WASTE WATER TREATMENT AND REUSE

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E21	**SEWAGE AND WASTE WATER TREATMENT AND REUSE**	Elective	3	1	0	3	4	75

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

UNITS	Course Details
UNIT 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
UNIT II: DISINFECTION	Disinfection: Introduction to disinfection and sterilization: Disinfectant - UV radiation - Chlorination - Antisepsis - Sterilant - Aseptic and sterile - Bacteriostatic and Bactericidal - factors affecting disinfection.
UNIT 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)
UNIT IV: PHYSICAL DISINFECTION	Physical Disinfection: Introduction - Ultraviolet Radiation - Solar Disinfection - Heat Treatment - Filtration Methods - Distillation - Electrochemical Oxidation Water Disinfection by Microwave Heating.
UNIT V: INDUSTRIAL VISIT	Industrial visit – data collection and analysis - presentation
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Drinking water and disinfection technique, Anirudhha Balachandra. CRC press (2013) 2. Design of Water and Wastewater Treatment Systems (CV-424/434), Shashi Bushan, Jain Bros (2015) 3. Integrated Water Resources Management, Sarbhukan M M, CBS PUBLICATION, (2013) 4. Environmental Pollution Control Engineering, C.S. Rao, New Age International, 3rd Edition, 2018 5. Pollution control in process industries, S.P. Mahajan, Tata McGraw Hill Publishing Company Ltd., 27th Ed, 2012.
REFERENCE BOOKS	1. Handbook of Water and Wastewater Treatment Plant Operations, Frank. R Spellman, CRC Press, IVth Edition, 2020 2. Wastewater Treatment Technologies, Mritunjay Chaubey, Wiley, 1st Edition, 2021. 3. Wastewater Engineering, Metcalf and Eddy, McGraw Hill Higher Edu., 4th ed., 2017. 4. Industrial Water Pollution Control,W. Wesley Eckenfelder, Jr., McGraw Hill Inc., IIIrd Edition, 1999. 5. Green Chemistry: An Introductory Text, Lancaster, RSC publishing, 2nd edition, 2010.
WEB SOURCES	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=Cj0KCQjwuuKXBhCRARIsAC-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJjxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gained knowledge in solid waste management	**K1** **K2** **K3** **K4** **K5** **K6**
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	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

ELECTIVE - LIST 3 – 22. SOLAR ENERGY UTILIZATION

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E22	**SOLAR ENERGY UTILIZATION**	Elective	3	1	0	3	4	75

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

UNITS	Course Details
UNIT I: HEAT TRANSFER & RADIATION ANALYSIS	Conduction, Convection and Radiation – Solar Radiation at the earth's surface - Determination of solar time – Solar energy measuring instruments.
UNIT 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.
UNIT III: SOLAR HEATERS	Types of solar water heater - Solar heating system – Collectors and storage tanks – Solar ponds – Solar cooling systems.
UNIT 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.
UNIT V: NANOMATERIALS IN FUEL CELL APPLICATIONS	Use of nanostructures and nanomaterials 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
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Solar energy utilization - G.D. Rai, Khanna publishers, 1995. 2. Carbon Nano forms and Applications, Maheshwar Sharon, Madhuri Sharon, Mc Graw-Hill, 1st Edition, 2010. 3. Solar Energy Engineering: Processes and Systems, Soteris A. Kalogirou, Academic Press, 2009

	4. Solar Energy – Fundamentals Design, Modelling and applications, G.N. Tiwari, Alpha Science International Ltd, Revised Edition, 2013. 5. Solar Energy, S.P. Sukhatme, Tata McGraw Hill Publishing Company Ltd, 3rd edition, 2008.
REFERENCE BOOKS	1. Energy- An Introduction to Physics – R.H.Romer, W.H.Freeman, 1976 2. Solar energy thermal processes, photovoltaics and wind – John A.Drife and William, Wiley, 5th edition, 2020 3. Renewable Energy Resources, John W. Twidell & Anthony D.Weir, Routledge, 3rd edition, 2005 4. John A. Duffie, William A. Beckman, Solar Energy: Thermal Processes, 4th Edition, john Wiley and Sons, 2013
WEB SOURCES	1. https://books.google.vg/books?id=l-XHcwZo9XwC&sitesec=buy&source=gbs_vpt_read 2. www.nptel.ac.in/courses/112105051 3. www.freevideolectures.com 4. http://www.e-booksdirectory.com

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Gain knowledge in fundamental aspects of solar energy utilization	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Understand the physical principles of solar collectors	
CO3	Develop fundamental skill on solar heater	
CO4	Understand the basic principle of different types of solar cells	
CO5	Demonstrate the use of nanotechnology in solar energy conversation	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

SKILL ENHANCEMENT COURSES

SKILL ENHANCEMENT COURSE - LIST 4 – 1. DESIGN AND INSTALLATION OF SOLAR PHOTOVOLTAIC SYSTEM

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E23	**DESIGN AND INSTALLATION OF SOLAR PHOTOVOLTAIC SYSTEM**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives

- To provide the basics and applications of photovoltaic systems.
- To identify safety hazards of photovoltaic systems.
- To identify practices and protective equipment used for PV systems installation and maintenance.
- To demonstrate solar energy fundamentals
- To conduct site assessments and planning for PV systems installations

UNITS	Course Details
UNIT I: PV SYSTEM BASICS	Introduction to Renewable energy - Basics of Electricity- Solar Radiation Basics and Measurement - Solar Path- Photovoltaic system types-Working of Solar Cells- Solar PV Modules-Solar PV Module Arrays-combiner box-Surge protection- meters and instruments.
UNIT II: ELECTRICAL SYSTEM DESIGN	Basics of Charge Controller-Inverter Basics-Solar Batteries- audit an electricity bill-Site audit & assessment-Components Selection-Balance of Systems Components.
UNIT III: SAFETY SYSTEM	Safety in Installation of Solar PV Systems-Solar PV Systems Design and integration -PV Battery System Design-PV Controller System Design-PV Inverter System Design.
UNIT IV: DEVICE INSTALLATION	Photovoltaic System Sizing -Solar PV Plant Installation Check List-Installation of Solar PV Power Plants -Plant Operation and Maintenance-Troubleshooting of Solar PV Power Plants.
UNIT V: PV DESIGN CONSIDERATIONS	Site inspection - shade calculations - roof assessments-solar panel location and spacing, floodplains, power line and battery locations - circuit boxes-pros and cons of rooftop and ground-mounted systems.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Large-Scale Solar Power System Design (Green Source Books): An Engineering Guide for Grid-Connected Solar Power Generation, Peter Gevorkian, Mcgraw-hill's resource Series, 2011. 2. Designing & Installing Solar PV Systems (Electronic PDF Textbook), Jay Warmke – 2nd edition (ISBN: 978-1-957113-03-6 electronic), 2022. 3. Solar PV System: Design, Installation, Operation and Maintenance, L.Ashok Kumar, K. Mohana Sundaram, Nova Publication, 2011. 4. Solar Power Systems Design From the Sun Into Electricity, Taleb Al-theanat, Global Institute of Electrical Engineering | GIEE, 2017.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Understand the characteristics of different PV system configurations	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Calculating PV module parameters using module specifications	
CO3	Study various PV technologies and their applications.	
CO4	Analyzing photovoltaic system performance	
CO5	Calculating photovoltaic array and BOS component sizing	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

SKILL ENHANCEMENT COURSE - LIST 4 – 2. ANALYTICAL INSTRUMENTAL METHODS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E24	**ANALYTICAL INSTRUMENTAL METHODS**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives

- To interpret the measurements and interpret the different types of errors.
- To understand the operating principles, construction and working of various analytical instruments.
- To able to analyze the different property of surface of materials
- To get an insight on the basic principles to application of different optical analysis
- To probe the electrochemical property and fabricate electrochemical cells

UNITS	Course Details
UNIT I: ERRORS AND ANALYSIS OF EXPERIMENTAL DATA	Types of errors – Mean, variance - standard deviation – sampling techniques. Thermal Analysis- Thermo gravimetric analysis – instrumentation of weight loss and decomposition products – differential scanning calorimetric – instrumentation – specific heat capacity.
UNIT II: ELECTRICAL METHODS	Electrical Methods: Hall Effect – carrier density – resistivity – two probe and four probe methods – scattering mechanism – Schottky barrier capacitance – impurity concentration – limitations.
UNIT III: SURFACE MICROSCOPY	Study of surfaces- Principle – Instrumentation – sample preparation – analysis of materials - Applications of SEM, TEM, AFM and STM.
UNIT IV: OPTICAL ANALYSIS	Photoluminescence – light-matter interaction – fundamental transitions – excitons – instrumentation – electroluminescence – instrumentation- Principle of UV-DRS and UV-Visible – sample preparation – analysis of materials-applications
UNIT V: ELECTROCHEMICAL ANALYSIS	Electrochemical cells- cell potentials - potentiometry - reference and counter electrode- instrument for potentiometric studies -cyclic and pulse voltammetry- application of voltammetry
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Instrumental Methods of Analysis - Willard. M, Steve. D, CBS Publishers, New Delhi, 1986. 2. Instrumental Method of Analysis, Willard, Hobart, et al, Wadsworth Publishing Co Inc, VII th Edition, 2001. 3. Electron Microscopy and Microanalysis of Crystalline materials ,R.A Stradling, Applied Science Publishers, London, 1979. 4. Electron microscopy and Microanalysis of Crystalline Materials, J.A Belk, Applied Science Publishers, London, 1st Edition, 1979.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Interpret the measurements and interpret the different types of errors.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Understand the operating principles, construction and working of various analytical instruments.	
CO3	Able to analyse the different properties of surface of materials	
CO4	Get an insight into the basic principles of application of different optical analysis	
CO5	Probe the electrochemical property and fabricate electrochemical cells	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

SKILL ENHANCEMENT COURSE - LIST 4 – 3. INDUSTRIAL SEMICONDUCTOR DEVICES

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E25	**INDUSTRIAL SEMICONDUCTOR DEVICES**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives

- Familiarize with semiconductor basics and device fabrication steps
- To develop background knowledge and core expertise related to lithography
- Understand the basic concepts involved in the fabrication technique.
- Acquire knowledge and apply it to MEMS technology
- To understand the parameters and applications of Regulated Power Supplies

UNITS	Course Details
UNIT I: FUNDAMENTALS OF MICRO AND NANO FABRICATION	Crystal Structure and Crystal Defects of semiconductor substrates- Bridgman Growth- Float Zone Growth- Wafer Preparation. Substrate -Introduction to cleanroom - Advanced cleaning techniques
UNIT II: LITHOGRAPHY	Overview- Diffraction- Source Systems and Spatial Coherence- Projection Printers- Advanced Mask Concepts- Surface Reflections and Standing Waves- Alignment
UNIT III: ETCHING	Wet Etching- Chemical Mechanical Polishing- High-Pressure Plasma Etching- Reactive Ion Etching- Damage in Reactive ion Etching- High-Density Plasma (HDP) Etching.
UNIT IV: MEMS	Fundamentals of Mechanics- Stress in Thin Films- Mechanical to Electrical Transduction- Mechanics of Common MEMS Devices- MEMS Actuators- High-Aspect Ratio Microsystems Technology.
UNIT V: REGULATED POWER SUPPLIES	Supply characteristics- Shunt regulators- Series regulators- monolithic linear regulator- current boosters- DC to AC converters- switching regulators.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Semiconductor Devices Physics and Technology - S. M. Sze, Wiley Publication, 2nd Edition, 1985. 2. Physics of semiconductor devices - S.M. Sze and Kwok K. NgWiley, Third Edition, 2007. 3. A Text Book of INDUSTRIAL ELECTRONICS V. G. Yangalw, Published By nirali prakashan,2018. 4. ELECTRONICS Semiconductor Physics and Devices: Basic Principles- D. A. Neamen, McGraw-Hill, 3rd Edition, 2003.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Provide the basic knowledge and also an overview of fundamentals fabrication	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Study the sources and basic concepts of lithography	
CO3	Gain knowledge in design techniques of etching	
CO4	Acquires an ability to analyse and design MEMS.	
CO5	Develop the fundamental concepts and techniques used in regulated power supplies.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

SKILL ENHANCEMENT COURSE - LIST 4 – 4. SILICON WAFER TECHNOLOGY FOR PHOTONICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E26	**SILICON WAFER TECHNOLOGY FOR PHOTONICS**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives
➢ To provide students with a comprehensive understanding of the principles and techniques of silicon wafer technology for photonics. ➢ To familiarize students with the unique properties and advantages of using silicon as a material platform for photonic devices. ➢ To introduce students to the fabrication processes and design considerations for silicon photonic devices. ➢ To explore the various types of silicon-based photonic devices and their applications in optical communications, sensing, and biophotonics. ➢ To examine the challenges, emerging trends, and future prospects in the field of silicon photonics.

UNITS	Course Details
UNIT I: INTRODUCTION TO SILICON WAFER TECHNOLOGY AND PHOTONICS	Introduction to silicon wafer technology - relevance in photonics - light-matter interactions and photonic devices - silicon as a material platform for photonics – Introduction to optical waveguides- properties in silicon photonics- silicon photonic circuits
UNIT II: SILICON-BASED PHOTONIC DEVICES	Silicon photonics modulators: Mach-Zehnder interferometers- ring resonators- and electro-optic effects- Silicon-based photodetectors and photodiodes -Silicon light sources: lasers and LEDs - Silicon photonic switches and routers-Performance metrics and characterization
UNIT III: SILICON PHOTONICS FOR OPTICAL COMMUNICATIONS	Overview of optical communication systems- Silicon photonics transceivers and modulators for high-speed data transmission- Wavelength division multiplexing (WDM) systems -silicon photonics integration- Silicon-based optical interconnects for data centers- Challenges and future trends - commercial applications in optical communications
UNIT VI: SILICON-BASED PHOTONIC INTEGRATED CIRCUITS	Introduction to photonic integrated circuits (PICs)- Silicon photonics platform: silicon-on-insulator (SOI) -complementary metal-oxide-semiconductor (CMOS) compatibility-PIC design -Fabrication processes for silicon-based PICs- Fabrication techniques for silicon photonic devices- PIC packaging and assembly techniques- Emerging trends and their applications

UNIT V: SILICON PHOTONICS FOR SENSING AND BIOPHOTONICS	Introduction to Silicon photonic biosensors- principles and designs-Label-free sensing techniques -applications-Silicon photonics for chemical sensing - environmental monitoring-Biomedical applications of silicon photonics-Advances in silicon photonics -sensing and biophotonics-Future prospects and challenges.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Silicon Photonics: An Introduction, Dinesh Bhatia, CRC Press, 1st Edition, 2019. 2. Silicon Photonics: Principles and Practices, R.K. Shevgaonkar and N. K. Viswanathan, McGraw-Hill Education, 1st Edition, 2018. 3. Silicon Photonics: Fundamentals and Devices, Graham T. Reed and Andrew P. Knights, Wiley, 1st Edition, 2012. 4. Silicon Photonics: An Introduction, Shuji Ikeda and Yuriko Maegami, Springer, 1st Edition, 2020. 5. Silicon Photonics: Principles and Practices, Prakash Prasad, CRC Press, 1st Edition, 2012.
REFERENCE BOOKS	1. Silicon Photonics: The State of the Art, Graham T. Reed and Andrew P. Knights, Wiley, 1st Edition, 2008. 2. Introduction to Silicon Photonics, Anuj Dhawan and Vivek Raghunathan, Springer, 1st Edition, 2016. 3. Foundations of Silicon Photonics, BahramJalali and SasanFathpour, Cambridge University Press, 1st Edition, 2018. 4. Silicon Photonics: Advanced Devices and Applications, Lorenzo Pavesi and David J. Lockwood, Springer, 1st Edition, 2013.
WEB SOURCES	1. Silicon Photonics Group at the University of California, Santa Barbara: https://www.ece.ucsb.edu/~markrodwell/si-photonics.html 2. MIT Silicon Photonics Group: http://siliconphotonics.mit.edu/ 3. Optics and Photonics News: https://www.osa-opn.org/home/ 4. SPIE (International Society for Optics and Photonics): https://spie.org/ 5. Photonics Online: https://www.photonics.com/ 6. Nanophotonics: https://www.nature.com/nphoton/

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Gain knowledge of the principles of silicon wafer technology and its relevance to photonics.	**K1 K2 K3 K4 K5 K6**
CO2	Familiar with a range of silicon-based photonic devices, including modulators, detectors, light sources, and integrated circuits, and understand their functionalities.	
CO3	Able to design and simulate simple silicon photonic components and circuits using appropriate software tools.	
CO4	Grasp the awareness of the applications of silicon photonics in optical communications, sensing, and biophotonics	
CO5	Contribute to research and development in the field of silicon wafer technology for photonics, or pursue further studies in related areas.	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	2
CO2	3	3	2	3	3
CO3	3	3	2	3	2
CO4	3	3	2	3	3
CO5	3	3	2	3	3

SKILL ENHANCEMENT COURSE - LIST 4 – 5. BIOMATERIALS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E27	**BIOMATERIALS**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives

- Understand how the basic engineering materials can be used as the biomaterials
- Apply and transfer interdisciplinary approaches in the biomedical field and others
- Gain knowledge on calcium phosphate biomaterials
- Study the different characterization techniques to analyze biomaterials
- Know the different applications of biomaterials

UNITS	Course Details
UNIT I: INTRODUCTION TO BIOMATERIALS	Biomaterials - historical development- impact of biomaterials -metals (stainless steels – cobalt chromium alloys -titanium based alloys) – ceramics-surface reactive ceramic- resorbable ceramics (Calcium phosphate based ceramic materials)
UNIT II: POLYMERIC BIOMATERIALS	Synthetic polymers and its biomedical use - Hydrogel - Polyurethanes - Polyamides – biopolymers - collagens- Gelatin - Chitin and chitosan - Alginate - Cellulose
UNIT III: CALCIUM PHOSPHATE CERAMICS	Chemistry of calcium phosphate bioceramics – preparation, mechanical properties and biological performance of tri-calcium phosphate, biphasic calcium phosphate, hydroxyapatite and other phosphates - calcium phosphate bone cements – preparation, properties - setting behavior and bio compatibility.
UNIT VI: CHARACTERIZATIONS OF BIOMATERIALS	Characterization of biomaterials - X-ray diffraction - Fourier transform infrared spectroscopy- scanning electron microscopy- transmission electron microscopy - thermal analysis: TGA, DSC and DTA- Elemental analysis: XRF and ICP- density and porosity measurements- microhardness
UNIT V: APPLICATIONS OF BIOMATERIALS	Tissue grafts - tissue engineering – biosensors - drug delivery systems- orthopedic implants - knee joint repair - dental implants - oral implants, bioprobes.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Biomaterials, Sujata V. Bhat, Narosa Publishing House, 2nd Edition, 2005. 2. Bioceramics and their clinical applications, T. Kokubo, Woodhead Publishing Limited, Cambridge, 2008. 3. Biomaterials: A Nano Approach, S. Ramakrishna, M. Ramalingam, T.S. Sampath Kumar,W.O. Soboyejo, CRC press, 2010. 4. Adsorption analysis: equilibria and kinetics, Vol. 2, Duong D. Do., Imprical college press, 1998. 5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng, John Wiley & Sons, 2009.
REFERENCE BOOKS	1. Biomaterials - Principles and Applications, Park J. B and Bronzino J. D., CRC press, 2002. 2. Biomaterials Science: An Introduction to Materials in Medicine, Ratner. B, Hoffman. A, Schoen. F, Lemons. J, Academic Press , 2004. 3. Biomaterials for artificial organs, Michael Lvsaght and Thomas J.Webster, Woodhead publishing Limited, 2011.

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand how the basic engineering materials can be used as the biomaterials.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Apply and transfer interdisciplinary approaches in the biomedical field and other fields.	
CO3	Know about calcium phosphate ceramics	
CO4	Analyze biomaterials with different analytical techniques	
CO5	Know the applications of biomaterials	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

SKILL ENHANCEMENT COURSE - LIST 4 – 6. POWDER X-RAY DIFFRACTION AND ANALYSIS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1E28	**POWDER X-RAY DIFFRACTION AND ANALYSIS**	Skill Enhancement	3	1	0	2	4	75

Learning Objectives

- To make understand X-rays, diffraction, crystal lattice and symmetry.
- To acquire background knowledge on X-ray diffraction from powder crystalline samples.
- To develop background knowledge on point groups
- To acquire knowledge and apply it to identify the structural parameters of crystals
- To understand XRD pattern interpretation

UNITS	Course Details
UNIT I: X-RAYS	X-rays-Charcteristics-Absorption and Filtering- Selection of Radiation- X-Ray tubes: Construction and Geometry-Monochrmatic X-rays – Safety of X-rays
UNIT II: CRYSTAL, PLANES, LATTICES AND X-RAY DIFFRACTION	Crystals-Lattices, Planes and Indices-X-Ray Diffraction- Bragg's Law- Crystal systems - Non-primitive Lattices
UNIT III: RECIPROCAL LATTICE AND CRYSTAL SYMMETRY	Reciprocal Lattice- Bragg's law in reciprocal lattice-Point group and space group symmetry
UNIT IV: POWDER X-RAY DIFFRACTOMETER	Method of Recording X-Ray diffraction: X-ray Diffractometer: X-Ray source- Goniometer- Video camera or Microscope- X-ray detector system-Host computer.
UNIT V: POWDER X-RAY DIFFRACTION AND ANALYSIS	Principle of powder diffraction- powder diffraction pattern-Interpretation of powder photographs-Applications- Limitations.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Powder Diffraction: Theory and Practice -R E Dinnebier, S J L Billinge, Royal Society of Chemistry, 1st Edition, 2008. 2. Introduction to X-Ray Powder Diffractometry -Ron Jenkins, Wiley-Interscience, 1st Edition, 1996.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Know the production of X-rays and diffraction from crystals and symmetry.	**K1** **K2** **K3** **K4** **K5** **K6**
CO2	Record and Interpret the X-ray diffraction pattern of powder crystalline samples.	
CO3	Know about reciprocal lattice and crystal symmetry	
CO4	Understand the powder X-ray diffractometer	
CO5	Analyze powder X-ray diffraction pattern	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

NON MAJOR ELECTIVE COURSES

NME - LIST 5 – 1. ELECTRONICS IN DAILY LIFE

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1N01	**ELECTRONICS IN DAILY LIFE**	NME	3	1	0	2	4	75

Learning Objectives

- To provide an opportunity for the students from other curriculum to understand the Physics of Electronics
- To understand the construction and operating principles of Electrical, Electronic and communication devices.
- To acquire a knowledge to analyze and design popular electronic technologies.
- To present idea on antennas for communication systems with related issues.
- To know the safety mechanism on handling the electrical and electronic equipment.

UNITS	Course Details
UNIT I: FUNDAMENTALS OF ELECTRONIC COMPONENTS	Electrical and Electronic Symbols – passive and active components- Resistors – Capacitors- Resistance wale – Capacitor wale – Electrical quantities – Electrical formulas – Magnetism – Meters – Fuse wire Vacuum diodes - Transistors – Integrated chips.
UNIT II: ELECTRICAL APPLIANCES	Switch board – Main box – Metal circuit breakers (MCB) – AC – DC currents – Two Phase – Three Phase electrical connections- Method of Earthing – generators – uninterrupted power supply (UPS)- stabilizer – voltage regulators. Electrical devices: Iron box – Fan – Electrical Oven – water Heaters Air conditioners – Refrigerators – washing machines-.
UNIT III: ELECTRONIC HOME APPLIANCES	Radio – Audio taper veaulem, Classification of home appliances - speaker- televisions – VCR – CD Players – DVD – calculators – Computers – scanner – Printer – Digital Camera – LCD Projectors – Display devices.
UNIT IV: COMMUNICATION ELECTRONICS	Principles of optical fiber Cables (OFC) – Telephone – Mobile phones – wireless phone - Antenna - Internet - Intranet.
UNIT V: SAFETY MECHANISM	Handling Electrical appliances - Power saving methods –- Prevention Methods - Protection of Hi–Fi electronic devices.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Electronics and Mathematics Data book – S.S. Kamble, Allied publishers Ltd,1997. 2. Study of electrical appliances and Devices - Bhatia, Kanna Publications,

	Seventh Edition, 2014.

COURSE OUTCOMES:

At the end of the course, the student will be able to:

CO1	Understand the function of different components of electronic circuit.	**K1 K2 K3 K4 K5 K6**
CO2	Learn and acquire the basic knowledge of various home appliances such as Iron box, Fan, Electric oven etc., being used in day-to-day life.	
CO3	Study various display system and their applications.	
CO4	Learn the various elements of communication electronics such as Mobile radio, optical fibre, transmission lines, internet etc.,	
CO5	Gain knowledge on safe handling and prevention methods while handling electrical and electronic devices	
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

NME - LIST 5 – 2. GEOPHYSICS								
Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**Credits**	**Inst. Hours**	**Marks**
23UPPHY1N02	**GEOPHYSICS**	NME	3	1	0	2	4	75

Learning Objectives
➢ To understand origin of earth, ➢ To gain ideas about earth's magnetism with magnetosphere. ➢ To have the cognition about earth quake. ➢ To attain knowledge about earth temperature and its effect. ➢ To obtain the fundamental concept of gravitational anomalies.

UNITS	**Course Details**
UNIT I: EARTH PLANET	Different motions of the earth- gravity field of the earth- Clairaut's theorem- size and shape of earth- geochronology. Seismology and interior of the earth; variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth.
UNIT II: GEOMAGNETISM	Origin of earth's magnetism – elements of earth's magnetic field – inclination, declination and dib - earth's magnetic field – diurnal, annual and secular variations – magnetosphere.
UNIT III: SEISMOLOGY BASIC PRINCIPLES OF ELASTICITY AND WAVE MOTION	Primary Seismology wave (P-waves) and Elasticity wave (S-wave) – density within the earth – pressure distribution – variation of "g" and elastic constants - earth quakes – elementary ideas about Ritter's scale
UNIT IV: GEO-THERMAL EFFECT	Fundamentals concept of thermal conductivity – heat flow measurement of on ground level and ocean – heat flow gravity variation – temperature of the primitive earth – inner core – melting point – adiabatic temperature gradient.
UNIT V: GRAVIMETRY	Fundamental concepts of gravitational field – gravitational anomalies – use of gravitational anomalies in geophysical prospecting – petroleum and mineral survey – factors affecting gravitational field due to magnetic storms and cosmic ray showers Mammond and Faller method of absolute gravity measurement – principle and working.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Pedagogy – Concept and applications -J.Sehgal, Kalyani publishers, 2009. 2. Introduction to geophysics (mantle, core and crust) - George G. Garland, W.B. Saunder's company, 1979. 3. Physics and Geology - Jacobbs, Russel and Wilson, International Students Edition, Tata McGraw Hill, 1959.

	4. Rock Magnetism - Nagata, McGraw Hill Publications, 1961. 5. Geology - Debrin, McGraw Hill Publications, 2016.
REFERENCE BOOKS	1. Physics and Geology - A.J. Aitken, Tata McGraw Hill Publications, 1990. 2. Biography of the earth (Its past, present and future) - George Gamove, Macmillon Company Ltd, 2017.
WEB SOURCES	1. https://www.geokniga.org/bookfiles/geokniga-basic-geophysics.pdf 2. https://alamrigeo.com/wp-content/uploads/2020/11/Principles-of-Geophysics.pdf 3. https://ahmedrehanhashmi.files.wordpress.com/2016/06/the-solid-earth-an-introduction-global-geophysics.pdf

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand the origin of earth.	**K1**
CO2	Understand the earth's magnetism and its implications.	**K2**
CO3	Acquire knowledge earth's elasticity, wave motion and earth quake.	**K3**
CO4	Explain earth's thermal effect.	**K4**
CO5	Understand gravimetry and geological survey for minerals and oils.	**K5** **K6**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	2	3	2
CO2	3	3	2	3	3
CO3	3	3	2	3	2
CO4	3	3	2	3	3
CO5	3	3	2	3	3

NME - LIST 5 – 3. MOLECULAR BIOPHYSICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1N03	**MOLECULAR BIOPHYSICS**	NME	3	1	0	2	4	75

Learning Objectives

- To study the chemical binding of molecules
- To have the basic knowledge about the cells and molecules
- To elucidates the health and disease-related mechanisms at the molecular and even atomic levels.
- To understand the physics of biomolecules and Bioenergetics
- To learn the memory system

UNITS	Course Details
UNIT I: CHEMICAL BINDING	Quantum mechanics-Pauli exclusion Principle – Ionisation energy – electron affinity – chemical binding – electro negativity – strong bonds – secondary bonds. Energies, Forces and Bonds: Interatomic potentials for strong bonds – weak bonds – non-central forces – bond energies – spring constants. Rates of reaction: Free energy – Internal energy – thermodynamics – statistical mechanics – reaction kinetics – water, acids, bases and aqueous reactions – radiation energy.
UNIT II: CELL: ITS ORGANELLS AND MOLECULES	Prokarytes and Eukaryotes molecular components of cell carbohydrates-lipids-proteins-nucleic acids- Macromolecular structure: Proteins: Amino acid and primary structure – peptide bond and secondary structure- α-helix and β- sheet - tertiary and quaternary structure of proteins-protein folding-Virus structure.
UNIT III: PHYSICS OF BIOMOLECULES	Molecular mechanism of Genetic information transfer-Genetic code – transfer of Genetic information – molecular mechanism of Protein synthesis - Principle of molecular recognition. Physics of Biological Membranes: Cell membrane –Structure of membranes-transport through membrane – Passive transport – diffusion – active transport-molecular reception
UNIT IV: BIOENERGETICS	Energy consumption - cellular respiration-photosynthesis – photosystem I & II ATP synthesis. Movement of Organisms: Bacterial motion – chemical memory in primitive organisms – muscular moment – Human performance. Excitable membranes: diffusion and mobility of Ion Resting potential . Nerve signals: Passive response – Nerve impulses (Auction Potentials) –the nervous system.
UNIT V: MEMORY	Hebbianlearing – Neural network – Auto-association. Control of movement: The Primacy of movement – Ballistic control in a simplified visual system – more sophistical modes of control – the Heterogeneous structures of muscle fibers – central pattern generators – conditional reflexes – volition and tree will – what purpose does consciousness serve – passive verses active in mental processing – the

	relevant anatomy and physiology – intelligence and creativity.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Biophysics: An Introduction -Rodney - M.J. Cotterill, John Wiley Publication, 2002. 2. Biophysics – Vasantha Pattabhi and N. Gautham, Alpha Science International, 2nd edition, 2009. 3. Biophysics - Roland Glacer, Springer Publications, 2012. 4. Elementary Biophysics an Introduction - P. K. Srivastava, Alpha Science International, 2005. 5. Biophysics - M. V. Volkenshtein, Mir Publications, 1983.
REFERENCE BOOKS	1. Physical chemistry:Principles and applications in Biological Sciences- I. Tinoco et al.,Pearson Education,2014 2. Molecular and Cellular Biophysics-M.B. Jackson, Cambridge University Press, 2006. 3. Protein Physics: A course of Lectures-A.V. Finkelstein and O.B. Ptitsyn, Academic Press, 2nd Edition, 2016. 4. Bioinformatics: Sequence and Genome Analysis-D.W. Mount, CSHL Press, 2nd Edition, 2004. 5. Biophysics: Principles and Techniques – M.A. Subramonian, MJP Publishers, 2005.
WEB SOURCES	1. https://blanco.biomol.uci.edu/WWWResources.html 2. https://learn.genetics.utah.edu/ 3. https://www.biology-pages.info/ 4. https://biologydictionary.net/ 5. https://www.cambridge.org/core/books/fundamentals-of-polymer-physics-and-molecular-biophysics/C73E0E826DE59C75457D4C2156B03087

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Interpret the chemical binding	**K1**
CO2	Explain the cells and their structures	**K2**
CO3	Understand the physics of biomolecules	**K3**
CO4	Acquire the knowledge of bioenergetics	**K4** **K5**
CO5	Understand the memory system and its functions	**K6**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

NME - LIST 5 –4-NON-LINEAR OPTICS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1N04	**NON-LINEAR OPTICS**	NME	3	1	0	2	4	75

Learning Objectives
➢ To accumulate knowledge of the nonlinear optics and basic level theoretical aspects.
➢ To learn important of NLO Materials and applications
➢ To grasp theories behind the nonlinear optical processes
➢ To gain Knowledge about nonlinear optical instrumentation
➢ To get knowledge in nonlinear optical instrumentation for research application

UNITS	Course Details
UNIT I: BASICS OF NONLINEAR OPTICS	Introduction to Linear Optics- Wave propagation in linear medium and Anisotropic Medium- response of materials to light -Nonlinear Frequency Mixing
UNIT II: THEORY OF HARMONICS IN NLO MATERIALS	Response of a Harmonic Oscillator- Second Harmonic Generation--Phase Matching-Frequency Conversion- Nonlinear Optical Susceptibilities- Nonlinear Optical Materials-Organic Nonlinear Optical Material- Applications of Nonlinear Optical materials.
UNIT III: HARMONICS GENERATION	Second-order harmonics generation (SHG) - optical rectification- Sum-frequency generation (SFG)- Difference-frequency generation (DFG)- Higher harmonics generation (HHG)- Third order harmonics generation
UNIT IV: LINEAR AND NONLINEAR SUSCEPTIBILITIES	Absence of χ (2) in centrosymmetric systems - Spatial symmetries and crystal classes - Constraints on the $\chi(1)$ and χ (2) tensors due to spatial symmetries - KDP example - Birefringence.
UNIT V: NONLINEAR INSTRUMENTATION	Kurtz and Perry technique- Nonlinear Refraction and Absorption- Higher order nonlinearity- Third-Order Nonlinearity Measurement Techniques: Z-Scan-Pulse propagation through third order nonlinear optical medium
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement
TEXT BOOKS	1. Nonlinear Optics, 3rd Edition, Robert W. Boyd, Elsevier Academic Press, 2007. 2. Nonlinear Fiber Optics, 4th Edition, G.P. Agarwal, Academic, 2007. 3. Electromagnetic Fields and Energy, Joseph W. Haus and Richard Boudreaux, Prentice Hall, 2000. 4. Nonlinear Fiber Optics, Govind P. Agrawal, Academic Press, 2001. 5. Introduction to Nonlinear Optics, Peter E. Powers, CRC Press,

	2012.
REFERENCE BOOKS	1. Handbook of Nonlinear Optics, 2nd Edition, R.L. Sutherland, Marcel Dekker, 2003. 2. Fundamentals of Nonlinear Optics, P.E. Powers, CRC Press, 2011. 3. Principles of Nonlinear Optics, Y.R. Shen, Wiley, 1984. 4. Nonlinear Optics, 4th Edition, N. Bloembergen, World Scientific, 1996. 5. Introduction to Nonlinear Laser Spectroscopy, Boris Lembrikov, Academic Press, 2003.
WEB SOURCES	1. https://www.rp-photonics.com/nonlinear_optics.html 2. http://www.boydnlo.ca/wp-content/uploads/2017/08/Tutorial%20on%20nonlinear%20optics.pdf 3. https://www.azooptics.com/Article.aspx?ArticleID=1373 4. http://top.electricalandcomputerengineering.dal.ca/PDFs/Web%20Page%20PDFs/ECED6400%20Lecture%20Notes.pdf 5. https://link.springer.com/chapter/10.1007/978-81-322-2000-8_2

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Develop a comprehensive understanding on the basic nonlinear Optics	**K1**
CO2	Learn how to utilize the nonlinear Optical Materials	**K2**
CO3	Understand the various process in nonlinear optics	**K3**
CO4	Understand the basics nature of linear and nonlinear susceptibilities	**K4** **K5**
CO5	Establish the knowledge of characteristics of the Nonlinear properties	**K6**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

NME - LIST 5 – 5. LASER PHYSICS AND APPLICATIONS

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
23UPPHY1N05	**LASER PHYSICS AND APPLICATIONS**	NME	3	1	0	2	4	75

Learning Objectives
➢ To study the Einstein's theory of Lasers.
➢ To get knowledge about Lasers characteristics and properties.
➢ To study the different type of Laser systems involving low density and high density gain media.
➢ To learn the Laser Spectroscopic Techniques and its Applications.
➢ To understand the Meteorological Applications such as Lidar, Satellite & Lunar Range finders.

UNITS	Course Details
UNIT I: **BASIC PHYSICS ON THE OPERATION OF LASERS**	Einstein's theory – Interaction of radiation with matter – Theory of some simple processes.
UNIT II: **LASER CHARACTERISTICS GAUSSIAN BEAM AND ITS PROPERTIES**	Stable two mirror optical resonators, Longitudinal and Transverse Modes of Laser cavity – Mode selection - gain in a Regenerative Laser cavity – Threshold for 3 and 4 level laser systems – Q Switching Mode locking pulse shortening _ Pico second & femto second. Operation – Spectral narrowing and stabilization.
UNIT III: **LASER SYSTEMS**	Laser systems involving low density gain media – Nitrogen Laser, Carbon dioxide Laser and Eximer laser. Laser systems involving high density gain media – Ruby Laser, Nd-YAG Laser, Semiconductor Laser, Diode Pumped Solid State Laser, Dye Laser High power semiconductor Diode Laser systems.
UNIT IV: **LASER SPECTROSCOPIC TECHNIQUES AND OTHER APPLICATIONS**	Laser fluorescence and Raman scattering and their use in Pollution studies, Non-linear interaction of light with matter, Laser induced multi photon processes and their applications, Ultra high resolution spectroscopy with laser and its applications, Propagation of light in a medium with variable refractive index, Optical Fibres. Light wave communication. Qualitative treatment of medical and Engineering applications of Lasers.

UNIT V: METEOROLOGICAL APPLICATION	Distance and range measurement – Lidar for range findings and tracking – pulsed laser sources – Configuration of a pulsed range finder – Range finding equation – Energy and power relation – signal detect ability – Switched lidars, Satellite and Lunar Range finders.
Extended Professional Component (is a part of internal component only. Not to be included in the external examination question paper)	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.
TEXT BOOKS	1. Principle of Lasers –Grazio Svelto, Plemum Press, Fifth Edition, 2008. 2. Laser Fundamentals - William Silfvast, Cambridge University Press, Second Edition, 2004. 3. Lasers and Non-linear Optics - B.B.Laud, Wiley Eastern Ltd, Third Edition, 2011. 4. Lasers - Lengyel, Wiley Inter Science, 1962. 5. Lasers: Fundamentals and Applications, Ajoy Ghatak, K. Thyagarajan, Springer Publication, 2010
REFERENCE BOOKS	1. Lasers in Chemistry, David L. Andrews, Springer-Verlag, Second Edition, 1990. 2. Medical Applications of Lasers: Laser ablation : principles and applications, John C. Miller, Publisher: Berlin ; New York : Springer Verlag, 1994. 3. Laser applications in medicine and biology, M. L. Wolbarsht, 4. Publisher: New York, Plenum Press, 1971 5. Optics and lasers : including fibers and optical waveguides, Matt Young, Publisher: Berlin ; New York : Springer-Verlag, 1992. 6. Lasers: Principles, Types and Applications, K. R. Nambiar, New Age International (P) Limited, 2006
WEB SOURCES	1. https://www.rp-photonics.com/encyclopedia.html 2. https://www.google.co.in/books/edition/Laser_Spectroscopy/5vuqvvb9YxkC?hl=en 3. https://en.wikipedia.org/wiki/Laser

COURSE OUTCOMES:

At the end of the course the student will be able to:

CO1	Understand and Interaction of radiation with matter	**K1**
CO2	Understand the Characterization of Lasers and their applications	**K2**
CO3	Understand the Laser systems involving high density media	**K3**
CO4	Differentiate Longitudinal and Transverse Modes of Laser cavity	**K4** **K5**
CO5	Get knowledge of Laser Raman scattering and their use in Pollution studies	**K6**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate; K6 - Create		

MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes **(CO)** for each course with program outcomes **(PO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
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

VALUE ADDED COURSE

OPTICAL SYSTEM ANALYSIS AND DESIGN

COURSE CODE: 23UPPHY1V01 **HOURS**: **30**

MAXIMUM MARKS: 100 **CREDITS: 2**

COURSE OBJECTIVES:

- Understands Image defects (Aberrations) in the optical systems.
- Comprehend variety of lens design and its tolerance analysis.

COURSE OUTCOME: After completion of the course, the students will be able to

CO1	Acquire the knowledge of optical functions and energy through computation.
CO2	Acquire basics of non-paraxial propagation of light and mirror focusing.

Mapping of course outcome with the programme outcome:

Course Outcome	PO1	PO2	PO3	PO4	PO5
CO1	M	L	H	M	L
CO2	L	H	M	M	L

Syllabus

Unit	Title	Intended learning chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Aberrations	Transverse ray and wave aberrations, chromatic aberration, Ray tracing: paraxial, finite and oblique rays, Image evaluation: transfer functions, point spread function, encircled energy and its computation and measurement, optimization techniques in lens design, merit function, Tolerance analysis; Double Gauss lens, Zoom lenses and aspheric lens.	15
II	GRIN optics	Focal shift, high and low N number focusing systems, focusing of light in stratified media, high numerical aperture focusing, basics of non-paraxial propagation of light. Classification of lens systems - Refractive systems - telephoto system, f-theta lens (fish eye lens); Reflective systems – single mirror telescope, two mirror telescope – three mirror aspheric system.	15

Books for Study and Reference

1. Principles of Computerized Tomographic Imaging, - A. C. Kak and Malcolm Slaney. IEEE Press, 1988.
2. Biomedical Optics: Principles and Imaging, - Lihong V. Wang and Hsin-i Wu. Wiley Interscience, 2007.

SOLAR PHYSICS

COURSE CODE: 23UPPHY1V02 **HOURS: 30**

MAXIMUM MARKS: 100 **CREDITS: 2**

COURSE OBJECTIVES:

- Conceptualize Physics of the Sun and solar system. Students can be able to understand the photosphere, chromospheres, corona, and solar activity. Also they can get the knowledge on interpretation and the role of solar eruption towards the earth-space weather astrophysical phenomenon.

COURSE OUTCOME: After completion of the course the students will be able to

CO1	Understand the photosphere, chromospheres, corona and solar activity
CO2	Get the knowledge on interpretation and the role of solar eruption towards the earth-space

Mapping of course outcomes with programme outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5
CO1	L	H	M	L	M
CO2	M	L	H	M	L

Syllabus

Unit	Title	Intended learning chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	The Sun	Anatomy of Sun-Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromospheres. Corona, -Basics of Solar Magneto-hydrodynamics. The solar family-Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model	15
II	Solar Eruptions	Solar Activity, Solar Cycle - Solar Storms - Solar flares - Solar Prominence - Corornal Mass Ejection- Types of CMEs - Earth and CMEs - Space Weather Change - Magnetic Belts - Satellites and CMEs.	15

Books for Study and Reference

1. Modern Astrophysics - B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co., 2007.
2. Introductory Astronomy and Astrophysics - M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing, 1998.
3. Textbook of Astronomy and Astrophysics with elements of cosmology - V.B. Bhatia, Narosa Publication, 2001.
4. Physics of Solar Flares and Coronal Mass Ejections - Dr. BojanVrnak, Create Space Independent Publishing Platform, 2015.

RADIATION PHYSICS

COURSE CODE: 23UPPHY1V03 **HOURS: 30**

MAXIMUM MARKS: 100 **CREDITS: 2**

COURSE OBJECTIVES:

- The objective of this course is to teach the basics of radiation physics and various radiation detectors.

COURSE OUTCOME: After completion of the course the students will be able to

CO1	Acquire knowledge on radiation and detection.
CO2	Determine the performance factors of various radiation detectors.

Mapping of the course outcomes with programme outcome

Course Outcome	PO1	PO2	PO3	PO4	PO5
CO1	M	M	H	L	M
CO2	L	M	L	H	M

Syllabus

Unit	Title	Intended Learning Chapters (K1, K2, K3, K4, K5, K6)	Hours of Instruction
I	Atomic Physics and Nuclear Transformation	Structure of matter - atom - nucleus -atomic mass and energy units -distribution of orbital electrons - atomic energy levels - nuclear forces -nuclear energy levels- particle radiation - Electromagnetic radiation- Binding energy - General properties of alpha, beta and gamma rays. Laws of equilibrium – modes of radioactive decay – nuclear isomerism -nuclear reactions - natural and artificial radioactivity - reactor and cyclotron produced isotopes - fission products – fusion.	15
II	Radiation Monitoring Instruments	Introduction – operational quantities for Radiation monitoring – Area survey meters –Ionization chambers – proportional counters – neutron area survey meters – GM survey meters – scintillation detectors – Personal monitoring – film badge – TLD –Properties of personal monitors – Radio photoluminescence glass dosimetry system -OSLD.	15

Books for Study and Reference

1. Radiation Oncology Physics: A Handbook for teachers and students. IAEA publications, 2005.
2. The Physics of Radiation Therapy - F.M. Khan, Third Edition, Lippincott Williams and Wilkins, U.S.A.,2003.
3. The Physics of Radiology - H. E. Jones, J. R. Cunningham and Charles C. Thomas, New York, 2002.
4. Fundamental Physics of Radiology - W. J. Meredith and J. B. Massey, John Wrightand Sons, U. K., 2000.
5. Medical Radiation Physics - W. R. Handee, Year Book Medical Publishers Inc.,London, 2003.
6. Principles of Radiological Physics - Donald T. Graham, Paul J. Cloke, Churchill Livingstone, 2003.

MODEL QUESTION PAPERS

Model Question Paper for Core Courses

23PGPHYC04

M.Sc. DEGREE EXAMINATION

Second Semester

Physics

QUANTUM MECHANICS

Time : Three hours Maximum: 75 marks

PART A - (20 x 1= 20 marks)
Answer ALL the questions

1. What is the unperturbed ground state energy (n=1) of normal helium atom?

W_H = 13.6eV. [CO1] [K2]

(a) -26.6 eV
(b) -54.4 eV
(c) -74.8 eV
(d) -27.2 eV

2. For the Anomalous Zeeman effect one of the following statements is true. [CO1] [K1]

(a) It does not include the spin

(b) It includes spin

(c) It is same as the normal Zeeman effect

(d) It is applicable only for the particle has spin zero

3. The energy of unperturbed simple harmonic oscillator for the state n=1 is [CO1] [K1]

(a) $E = \frac{1}{2}\hbar\omega$

(b) $E = \frac{1}{2}\hbar\omega$

(c) $E = \frac{3}{2}\hbar\omega$

(d) $E = \frac{5}{2}\hbar\omega$

4. The variation principle states that the ground state energy for the normalized wave functions is

(a) $< E > = E_0$ [CO1] [K2]

(b) $< E > \leq E_0$

(c) $< E > \geq E_0$

(d) $< E > \leq \frac{1}{2}\hbar\omega$

5. If the Hamiltonian of system is constant in time except for a very short time interval then the system may be described by [CO2] [K1]

(a) Sudden approximation
(b) Adiabatic approximation
(c) Time independent perturbation theory
(d) Variation method

6. Semi-classical theory treats [CO2] [K2]

(a) The motions of the atoms are to be classical and electromagnetic field is quantized.

(b) The motions of the atoms are quantized and electromagnetic field is classical.

(c) Both motion of atom and electromagnetic field are quantized.

(d) Both motions of atoms and electromagnetic field are classical.

7. The selection rules for the dipole transitions are [CO2][K1]

(a) $\Delta m = 1, \Delta l = \pm 1$

(b) $\Delta m = 0, \Delta l = \pm 1$

(c) $\Delta m = 2, \Delta l = \pm 2$

(d) $\Delta m = \pm 1, \Delta l = 1$

8. Fermi-Golden rule comprises that the transition probability [CO2] [K2]

(a) Proportional to square of harmonic perturbing term and the density of final states.

(b) Inversely proportional to square of harmonic perturbing term and the density of final states.

(c) Proportional to square of harmonic perturbing term.

(d) Equal to the $H'_{kn}\rho(E_k)$

9. Born approximation can be used in the problem of scattering where the [CO3] [K2]

(a) Potential of colliding particles are slowly varying

(b) Scattered wave is strong in amplitudes

(c) Scattered wave is weak in amplitudes

(d) The potential V(r) = 0

10. The optical theorem states the relation of [CO3] [K1]

(a) $\sigma_{Total} = 4\pi\ I_m\ f(\theta)$

(b) $\sigma_{Total} = \frac{4\pi}{k} I_m\ f(\theta)$

(c) $\sigma_{Total} = \frac{4\pi}{\hbar k} I_m\ f(\theta)$

(d) None of the above

11. If $\psi_k(r,\theta,\phi) = \underset{r\to\infty}{\overset{lim}{\longrightarrow}} e^{ik.r} + f(\omega)\frac{e^{ikr}}{r}$, the scattered function is [CO3] [K2]

(a) $e^{ik.r}$

(b) $\frac{e^{ikr}}{r}$

(c) $f(\omega)\frac{e^{ikr}}{r}$

(d) $f(\omega)$

12. For partial wave analysis method, correct option (s) is/are [CO3] [K1]

(a) Phase shift completely determine the scattering

(b) Scattering cross-section is zero when phase shift $\delta_l = 0°$

(c) Scattering cross-section is maximum when phase shift $\delta_l = 180°$

(d) Scattering cross-section is maximum when phase shift $\delta_l = 0°$

13. Klein-Gordan equation is considered not as a state equation but rather as the field equation of quanta associated with [CO4][K2]

(a) Spinless particles (b) Spin half particles
(c) Spin one particles (d) None of these

14. According to Dirac's theory, a position is [CO4] [K1]

(a) an occupied state of negative energy
(b) an unoccupied state of negative energy
(c) an occupied state of positive energy
(d) an unoccupied state of negative energy

15. Which of the following is correct [CO4][K2]

(a) Trace α_i =Trace $\beta = 0$
(b) Trace $\alpha_i = 0$ but Trace $\beta \neq 0$
(c) Trace $\alpha_i \neq 0$ but Trace $\beta = 0$
(d) Trace α_i =Trace $\beta \neq 0$

16. Choose the correct option(s) for $\hat{\alpha}$and $\hat{\beta}$ matrices [CO4][K1]

(a) $\alpha_x^2 = \alpha_y^2 = \alpha_z^2 = 1$ but $\beta^2 \neq 1$

(b) $\alpha_x^2 = \alpha_y^2 = \alpha_z^2 = 1$ but $\beta^2 = 1$

(c) Eigenvalues of $\hat{\alpha}$and $\hat{\beta}$ are ± 1

(d) Trace α_i= Trace $\beta = 0$

17. Which one of the following statement is Hund's rule [CO5][K2]

(a) Electrons are described as clouds and probability
(b) Pairing of electrons in the orbitals belonging to the same subshell does not take place until each orbital belonging to that subshell has got one electron each.
(c) No two electrons can have the same quantum number
(d) In the ground state of an atom or ion, electrons fill atomic orbitals of the lowest available energy levels before occupying higher levels

18. For an atom, which one of the statement is true for Born-Oppenheimer approximation [CO5] [K2]

(a) Both electrons and nuclei are stationary.
(b) Electrons are stationary and the nuclei in motion.
(c) Both electrons and nuclei are in motion.
(d) Nuclei as stationary while the electrons move around them.

19. Thomas – Fermi model assume that the [CO5] [K1]

(a) atom is a statistical one in which the electrons are treated as a gas obeying Bose-Einstein statistics and the potential is slowly varying.
(b) atom is a statistical one in which the electrons are treated as a gas obeying Fermi-Dirac statistics and the potential is slowly varying.
(c) atom is not statistical one in which the electrons are treated as a gas obeying Fermi-Dirac statistics and the potential is rapidly varying.
(d) None of the above.

20. If ψ_a and ψ_b are the atomic orbitals centred on ***a*** and ***b*** respectively of hydrogen molecule ion H_2^+ and the Hamiltonian of the system is H. Their Coulomb integrals are [CO5] [K2]

(a) $\langle\psi_a|\psi_a\rangle = H_{aa}$ and $\langle\psi_b|\psi_b\rangle = H_{bb}$
(b) $\langle\psi_a|H|\psi_b\rangle = H_{ab}$ and $\langle\psi_b|H|\psi_a\rangle = H_{ba}$
(c) $\langle\psi_a|H|\psi_a\rangle = H_{aa}$ and $\langle\psi_b|H|\psi_b\rangle = H_{bb}$
(d) $\langle\psi_a|\psi_b\rangle = H_{ab}$ and $\langle\psi_b|\psi_a\rangle = H_{ba}$

PART B – (3 x 5 = 15 marks)
Answer any THREE questions

21. Prove that for the ground state of hydrogen atom there is no first order Stark effect. [CO1] [K3]

22. Calculate the electric dipole transition probability for an atom placed in a radiation field. [CO2] [K4]

23. Using Born approximation determine the scattering cross-section for the weak scatterer and write the validity of this approximation. [CO3] [K3]

24. If $\vec{\alpha}$ represents three Dirac matrices $\alpha_x, \alpha_y, \alpha_z$ and $\vec{B}$ and $\vec{C}$ are usual three dimensional vectors, then show that [CO4] [K4]

$$(\vec{\alpha}.B)\ (\vec{\alpha}.C) = B.C + i\vec{\sigma}'.B \times C$$

where $\vec{\sigma}' = \begin{bmatrix} \vec{\sigma} & 0 \\ 0 & \vec{\sigma} \end{bmatrix}$ is a 4 x 4 matrix and $\vec{\sigma}$ being 2 x 2 Pauli's spin matries

25. What is LCAO approximation? List the conditions to be satisfied by the contributing atomic orbitals to generate an effective MO. [CO5] [K3]

PART C – (5 x 8 = 40 marks)
Answer ALL the questions

26. (a) Give the time independent perturbation theory for the degenerate case. [CO1][K5]

Or

(b) Discuss the normal Zeeman effect and write how it differ from anomalous Zeeman effect. [CO1][K5]

27. (a) Explain the time development of states using time dependent perturbation theory and obtain the probability amplitude for the system with the perturbation in constant time. [CO2][K5]

Or

(b) Outline the semi-classical theory of radiation using time dependent perturbation and derive the expression for transition probability for absorption and emission. [CO2][K5]

28. (a) Evaluate the scattering amplitude in the Born approximation for scattering by the Yukawa potential [CO3][K6]

$$V(r) = V_0\, e^{-\alpha r}/r$$

where V_0 and α are constants. Also show that $\sigma(\theta)$ peaks in the forward direction ($\theta = 0$) except at zero energy and decreases monotonically as θ varies from 0 to π.

Or

(b) Discuss the scattering length and effective range theory for low energy scattering. [CO3][K6]

29. (a) Derive the Klein-Gordan equation and explain its significance. [CO4] [K6]

Or

(b) Using Dirac's relativistic theory obtain the expression for the magnetic moment of electron. [CO4] [K6]

30. (a) Discuss the Hartree-Fock method. [CO5] [K5]

Or

(b) Using molecular orbital theory derive possible molecular orbital energies of the hydrogen molecule ion. [CO5] [K5]

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23PGPHYE02

Model Question Paper for Elective Courses

M.Sc. DEGREE EXAMINATION
First Semester
Physics
PHYSICS OF NANO SCIENCE AND TECHNOLOGY

Time: Three hours Maximum: 75 Marks

PART - A (20 x 1 = 20 marks)
Answer ALL questions

1. The limit of resolution of a microscope is given by [CO1][K2]
   (a) Wavelength of radiation (b) Magnifying power of eyepiece
   (c) Size of aperture (d) Polarization of radiation

2. Quantum confinement results in [CO1] [K1]
   (a) Energy gap in semiconductor is proportional to the inverse of the square root of size
   (b) Energy gap in semiconductor is proportional to the inverse of the size
   (c) Energy gap in semiconductor is proportional to the square of size
   (d) Energy gap in semiconductor is proportional to the inverse of the square of size

3. Which ratio decides the efficiency of nanosubstances? [CO1][K2]
   (a) Weight/volume (b) Surface area/volume
   (c) Volume/weight (d) Pressure/volume

4. The density of states for a zero dimensional system shows the variation like that of a [CO1] [K1]
   (a) δ-function (b) Exponential function
   (c) Step like behavior (d) Constant

5. Name the components in an amphiphile. [CO2][K2]
   (a) hydrophilic tail
   (b) hydrophobic head
   (c) hydrophilic tail and hydrophobic head
   (d) hydrophilic head and hydrophobic tail

6. Ceramics can conduct [CO2][K2]
   (a) heat (b) electricity (c) light (d) none of these

7. Reverse micelles are [CO2][K1]
   (a) Water-in-Oil (b) Oil-in-water (c) Oil+Polymer (d) None

8. What is the appropriate name of zero dimensional cadmium sulfide? [CO2] [K1]
   (a) Ceramic (b) Nanomembrane (c) Quantum dot (d) Quantum well

9. Choose the type of nanomaterials that is easy to magnetize and demagnetize while exposed to external magnetic field? [CO3] [K2]
   (a) Hard magnet (b) Soft magnet
   (c) Ferromagnets (d) All of the above

10. Which of the following magnetic material contains single domain particles? [CO3] [K2]
    (a) Superparamagnetic (b) Hard magnetic
    (c) Diamagnetic (d) Ferrimagnetic
11. Coercivity of super paramagnetic material is [CO3] [K1]
    (a) $\geq$ 100 Oe (b) 0 Oe (c) < 10 Oe (d) > 10 Oe
12. The nano particles from iron and palladium are used to produce [CO3][K2]
    (a) Magnets (b) Magnetic lens
    (c) Magnetometers (d) Magnetic storage devices
13. Which one of the following properties of nanoscale materials is suitable for catalytic applications? [CO4][K2]
    (a) High surface to volume ratio (b) High mechanical strength
    (c) Super plasticity (d) All of the above
14. The extensively used nanoparticles as catalyst is [CO4][K1]
    (a) Silver (b) Copper (c) Gold (d) Cerium
15. According to _____ model specific heat of solids at low temperature is proportional to the third power of absolute temperature. [CO4][K1]
    (a) Dulong-petit (b) Debye (c) Einstein (d) Sommerfield
16. The quantity of heat required to change the unit mass of a solid substance, from solid state to liquid state, while the temperature remains constant is known as [CO4][K1]
    (a) Latent heat (b) Sublimation
    (c) Hoar frost (d) Latent heat of fusion
17. Band gap engineered quantum devices are made-up of [CO5][K2]
    (a) III-V semiconductors (b) II-VI semiconductors
    (c) transition metals (d) magnetic nanoparticles
18. Molecular electronics operates in the quantum realm of distance [CO5][K2]
    (a) ~100 nm (b) ~ 100 m (c) ~1000 nm (d) ~1 m
19. Select the correct name of electron-hole pair from the given list? [CO5][K1]
    (a) Photon (b) Phonon (c) Exciton (d) Fermion
20. Carbon nanotube is a [CO5][K1]
    (a) Conductor (b) Insulator
    (c) Semiconductor (d) Impure metal

PART - B (3 x 5 = 15 marks)
Answer any THREE questions

21. What is single electron tunneling? Explain. [CO1][K3]
22. Explain the bonding and defects in ceramics. [CO2][K4]
23. Interpret the magnetic components inserted in semiconductor nanoscale solids. [CO3][K3]
24. Explain how the specific heat of a compound varies at nanoscale level. [CO4][K4]
25. Explain in detail about nanobots. [CO5][K3]

PART - C (5 x 8 = 40 marks)
Answer ALL questions

26. (a) How does the three dimensional (3D) density of states differs from the two dimensional (2D) and one dimensional (1D) density of states? Explain with the help of schematic and plots. [CO1][K5]

Or

(b) Explain in detail the electrical conductivity of palladium nanocluster. [CO1][K5]

27. (a) List out the physical, chemical and mechanical properties of ceramics. [CO2][K6]

Or

(b) Briefly explain the synthesis of cadmium telluride nano crystals. [CO2][K6]

28. (a) Give a detailed account of diluted magnetic semiconductor. [CO3][K5]

Or

(b) What are single domain particles? Give the salient features of single domain particles. [CO3][K5]

29. (a) Explain the melting temperature of nanomaterials in terms of thermodynamic predictions and atomic vibrations. [CO4][K5]

Or

(b) Discuss about the various nanostructured adsorbents. [CO4][K5]

30. (a) Discuss the applications of nanotechnology in photoelectrochemical cells. [CO5][K6]

Or

(b) Explain the various applications of nanomaterials as colorants and pigments. [CO5][K6]

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23PGPHYNE01

Model Question Paper for Non Major Elective Courses

M.Sc., and M.Tech DEGREE EXAMINATION
Second Semester
Physics
ELECTRONICS IN DAILY LIFE

Time: Three hours Maximum: 75 marks

PART A – (20 x 1= 20 marks)
Answer ALL the questions

1. Electricity is measured through a device called as [CO1][K1]
   (a) Ammeters (b) Voltmeters
   (c) Barometers (d) Anemometers
2. A suitable constant flow of electricity can be ensured through [CO1][K2]
(a) an ammeter (b) a rheostat
   (c) a voltmeter (d) a galvanometer

3. Conventionally, negative terminals are shown as [CO1][K1]
(a) a long thin line (b) a short fat line
   (c) a long wavy line (d) a short wavy line

4. A straight line symbol indicates the [CO1][K2]
(a) Fuse (b) Diode
   (c) Connecting lead (d) Switch

5. Which of the following refrigerant is widely used in domestic refrigeration? [CO2[K2]
(a) Oxygen (b) Ammonia (c) Neon (d) Alcohol
6. In a refrigerator, the lowest temperature occur at [CO2][K2]
(a) Condenser (b) Compressor
   (c) Evaporator (d) Expansion valve

7. In a electric iron, the transfer of heat from coil to base plate is mainly through [CO2][K1]
(a) Conduction (b) Convection (c) Radiation (d) Induction
8. The heating element in an electric iron is usually made of [CO2][K1]
(a) Brass (b)Iron (c) Nichrome (d) Platinum
9. Which material can be used up to a temperature of 130 °C? [CO3][K2]
(a) Mica (b) Cotton (c) Synthetic resin (d) Paper
10. Which alloy is used as electrical resistance alloy? [CO3][K1]
(a) Nickel alloys (b) Nickel chromium alloys
(b) Ferro nickel alloys (d) Zinc nickel alloys

11. Which among these is the application of universal motors? [CO3] [K2]

(a) Vacuum cleaners (b) Fans

(c) Hair dryers (d) Washing machines

12. The different types of analog recorders are [CO3] [K1]

(a) Graphic recorders (b) Oscillographic recorders

(c) Magnetic tape recorders (d) Compact disc recorders

13. In an optical fiber, the concept of numerical aperture is applicable in describing the ability of [CO4] [K2]

(a) Light Collection (b) Light Scattering

(c) Light Dispersion (d) Light Polarization

14. In an optical fiber communication system, which among the following is not a typical transmitter function? [CO4] [K2]

(a) Coding for error protection (b) Decoding of input data

(c) Electrical to optical conversion (d) Recoding to match output standard

15. The basic principle involved in light transmission through a fiber optic link is [CO4][K2]

(a) Total internal reflection (b) Polarization

(c) Diffraction (d) Refraction

16. The band of light wavelengths that are too long to be seen by the human ey [CO4][K1]

(a) Amber (b) Visible (c) Infrared (d) Ultraviolet

17. Probability of the event that might occur X Severity of the event if it occurs [CO5] [K1]

(a) Accident (b) Hazard (c) Risk (d) Stroke

18. For household wiring and small units, the following should be used for safety measure [CO5] [K1]

(a) MCB (b) ACB (c) OCB (d) MCCB

19. Which of the following colour is used for radiation hazard? [CO5][K2]

(a) Red (b) Orange (c) Green (d) Purple

20. Decibel (db) is a unit used to measure [CO5][K1]

(a) Light (b) Sound (c) Frequency (d) Heat

PART B – (3 x 5= 15 marks)
Answer any THREE questions

21. What is an integrated chip and give its advantages. [CO1][K3]

22. Draw a diagram of electrical switch board and describe its components. [CO2][K3]

23. Elucidate the function of transmitter and receiver in radios. [CO3][K4]

24. Illustrate and explain the basic principles of fibre-optic communication. [CO4][K4]

25. Describe potential accidents and hazards associated with the following equipment

(a) Portable generators (b) Battery charges [CO5][K3]

PART C – (5 x 8= 40 marks)
Answer ALL the questions

26. (a) What is resistor? Explain the circuit diagram with serial and parallel connections of resistors. [CO1][K5]

Or

(b) What is fuse wire? Discuss its types and significance in electrical appliances. [CO1][K5]

27. (a) Explain two phase and three phase electrical connections. [CO2][K6]

Or

(b) Elucidate the construction and working of electrical generators. [CO2][K6]

28. (a) With a neat diagram, explain the local area network and wide area network. [CO3][K5]

Or

(b) Write a brief account on input and output devices of computers. [CO3][K5]

29. (a) What a brief account of optical fibre? Explain the construction and working principle of optical communication. [CO4][K5]

Or

(b) Describe the single-mode and multi-mode fibre optical communication. [CO4][K5]

30. (a) Explain the function of electrical safety devices, fuse, circuit breakers and ground fault circuit interrupters. [CO5][K6]

Or

(b) Write the safety rules to be followed while handling the electrical appliances. [CO5][K6]

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INSTRUCTION TO PREPARE THE QUESTION PAPERS

Instruction to Prepare the Question papers

Question Paper Pattern (Theory)

PART	Approaches	Mark Pattern	K Level
A	One word (Answer all questions)	(20 x 1 = 20 (Multiple choice questions)	K1 & K2
B	100 to 200 words (Answer any three out of five questions)	3 x 5 = 15 (Analytical type questions)	K3 & K4
C	500 to 1000 words	5 x 8 = 40 (Essay type questions)	K5 & K6

Core courses

- PART A: Four questions from each unit and among all questions at least five questions must be problem.
- PART B: One question from each unit. In this section, among all questions at least two questions must be Problem and other questions are analytical type.
- PART C: Two questions from each unit. In this section, among all questions at least one question must be a problem, the remaining questions are descriptive.

Elective courses

- PART A: Four questions from each unit, all are objective type.
- PART B: One question from each unit, all are analytical type.
- PART C: Two questions from each unit, all are descriptive type.

Supportive courses

- PART A: Four questions from each unit, all are objective type.
- PART B: One question from each unit, all are analytical type questions.
- PART C: Two questions from each unit, all are descriptive type questions.