M.SC., PHYSICS

ManonmaniamSundaranar University

Affiliated Colleges - M.Sc Physics Syllabus
(With effect from the academic year 2023 – 2024onwards)

M.Sc. DEGREE COURSE IN PHYSICS
COURSE STRUCTURE

Preamble

The curriculum for the P.G. Physics for universities and colleges is revised as per Learning Outcomes- based Curriculum Framework (LOCF). The learner centric courses are designed to enable the students to progressively develop a good understanding of the concepts of various domains in physics. Significant modification is the inclusion of the courses to equip students to face challenges in industries and make them employable. Skill development in different spheres and confidence building are given a special focus.

TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M. Sc., Physics**
Programme Code	
Duration	**PG – 2YEARS**
Programme Outcomes (POs)	**PO1: Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society. **PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective. **PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.

Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions. **PSO 2 - Entrepreneur** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PSO3 – Research and Development** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit. **PSO 6** Students will utilize e-resources, digital tools and techniques for widening their knowledge base. **PSO 7** Students gain exposure to programming language and skills. **PSO 8** Student will appreciate the interplay of mathematics, physics and technology. **PSO 9** Students will develop adequate knowledge and skills for employment and entrepreneurship. **PSO 10** An awareness of civic and ecological duties as good citizens and importance of human values will be inculcated in students

Template for P.G., Programmes

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
Core-I	5	7	. Core-IV	5	6	Core-VII	5	6	Core-XI	5	6
Core-II	5	7	Core-V	5	6	Core-VIII	5	6	Core-XII	5	6
Core – III	4	6	Core – VI	4	6	Core – IX	5	6	Project with viva voce	7	10
Elective -I Discipline Centric	3	5	Elective – III Discipline Centric	3	4	Core – X	4	6	Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
Elective-II Generic:	3	5	Elective -IV Generic:	3	4	Elective - V Discipline Centric	3	3	Skill Enhancement course / Professional Competency Skill	2	4
			Skill Enhancement I	2	4	3.6 Skill Enhancement II	2	3	Extension Activity	1	
						3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**22**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -91											

Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System for all Post – Graduate Courses including Lab Hours

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
	Core – I	5	7
	Core – II	5	6
	Core – III	4	6
	Elective – I	3	6
	Elective – II	3	5
		20	**30**

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course - I	2	4
		22	**30**

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core –VII	5	6
	Core –VIII	5	6
	Core –IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity	2	-
		26	**30**

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	8
	Elective – VI (Industry Entrepreneurship)	3	6
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		23	**30**

Total 91 Credits for PG Courses

METHODS OF EVALUATION		
Internal Evaluation	Continuous Internal Assessment Test	**25 Marks**
	Assignments / Snap Test / Quiz	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	**75 Marks**
Total		**100 Marks**

METHODS OF ASSESSMENT	
Remembering (K1)	• Thelowestlevelofquestionsrequirestudentstorecallinformationfromthecoursecontent • Knowledgequestionsusuallyrequirestudentstoidentifyinformationinthetextbook.
Understanding (K2)	• Understandingoffactsandideasbycomprehendingorganizing,comparing,translating,interpolatingandinterpretingintheirownwords. • Thequestionsgobeyondsimplerecallandrequirestudentstocombinedatatogether
Application (K3)	• Studentshavetosolveproblemsbyusing/applyingaconceptlearnedintheclassroom. • Studentsmustusetheirknowledgetodetermineaexactresponse.
Analyze (K4)	• Analyzingthequestionisonethatasksthestudentstobreakdownsomethingintoitscomponentparts. • Analyzingrequiresstudentstoidentifyreasonscausesormotivesandreachconclusionsorgeneralizations.
Evaluate (K5)	• Evaluationrequiresanindividualtomakejudgmentonsomething. • Questionstobeaskedtojudgethevalueofanidea,acharacter,aworkofart,orasolutiontoaproblem. • Studentsareengagedindecision-makingandproblem–solving. • Evaluationquestionsdonothavesinglerightanswers.
Create (K6)	• Thequestionsofthiscategorychallengestudentstogetengagedincreativeandoriginalthinking. • Developingoriginalideasandproblemsolvingskills

M.Sc. DEGREE COURSE IN PHYSICS
COURSE STRUCTURE

FIRST SEMESTER

COURSE COMPONENTS	NAME OF THE COURSE	INST. HRS.	CREDITS	EXAM HRS.	MAX MARKS	
					CIA	EXT.
Core-I	Paper 1- Mathematical Physics	7	5	3	25	75
Core-II	Paper 2 - Classical Mechanics and Relativity	6	5	3	25	75
Core-III	Paper 3 - Linear and Digital ICs and Applications	6	4	3	25	75
Discipline Centric Elective- I	Practical I	6	3	6	50	50
Generic Elective-II:	Choose any one from the list I	5	3	3	25	75
		30	20			

SECOND SEMESTER

COURSE COMPONENTS	NAME OF THE COURSE	INST. HRS.	CREDITS	EXAM HRS.	MAX MARKS	
					CIA	EXT.
Core-IV	Paper 4– Statistical Mechanics	6	5	3	25	75
Core-V	Paper 5 - Quantum Mechanics –I	6	5	3	25	75
Core Practical-II/Core-VI	Practical – II	6	4	6	50	50
Discipline Centric Elective- II	Choose any one from the list II	4	3	3	25	75
Generic Elective - II	Choose any one from the lists III	4	3	3	25	75
SEC I	Physics for Competitive Examinations	4	2	3	25	75
		30	22			

ELECTIVE PAPERS

List 1

1. Energy Physics
2. Crystal Growth and Thin films
3. Analysis of Crystal Structures
4. Materials Science
5. Physics of Nano Science and Technology
6. Digital Communication
7. Communication Electronics

LIST 2

8. Plasma Physics
9. Bio Physics
10. Non-linear Dynamics
11. Quantum Field Theory
12. General Relativity and Cosmology
13. Advanced Optics
14. Advanced Mathematical Physics

LIST 3
INDUSTRY ORIENTED ELECTIVE (IOE)

15. Advanced Spectroscopy
16. Microprocessor 8086 and Microcontroller 8051
17. Characterization of Materials
18. Medical Physics
19. Solid Waste Management (SWM)
20. Sewage and Waste Water Treatment and Reuse
21. Solar Energy Utilization

Paper-1 - MATHEMATICAL PHYSICS	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	MATHEMATICAL PHYSICS	Core				5	7	75

Pre-Requisites
Matrices, vectors, differentiation, integration, differential equations
Learning Objectives
➢ To equip students with the mathematical techniques needed for understanding theoretical treatment in different courses taught in their program ➢ To extend their manipulative skills to apply mathematical techniques in their fields ➢ To help students apply Mathematics in solving problems of Physics

UNITS	Course Details
UNIT I: **LINEAR VECTOR SPACE**	Basic concepts – Definitions- examples of vector space – Linear independence - Scalar product- Orthogonality – Gram-Schmidt orthogonalization procedure – linear operators – Dual space- ket and bra notation – orthogonal basis – change of basis – Isomorphism of vector space – projection operator –Eigen values and Eigen functions – Direct sum and invariant subspace – orthogonal transformations and rotation
UNIT II: **COMPLEX ANALYSIS, PROBABILITY & STATISTICS**	Review of Complex Numbers -de Moivre'sTheorem-Functions of a Complex Variable- Differentiability -Analytic functions- Harmonic Functions- Complex Integration- Contour Integration, Cauchy – Riemann conditions – Singular points – Cauchy's Integral Theorem and integral Formula -Taylor's Series - Laurent's Expansion- Zeros and poles – Residue theorem. Probability – Introduction – Addition rule of probability – Multiplication law of probability – Problems – Introduction to statistics – Mean, median, mode and standard deviations.
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**	Definitions -Fourier transform and its inverse - Transform of Gaussian function and Dirac delta function -Fourier transform of 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 equation- Sturm-Liouville's theory - Series solution with simple examples - Hermite polynomials - Generating function - Orthogonality properties - Recurrence relations – Legendre polynomials - Generating function - Rodrigue formula – Orthogonality properties - Dirac delta function- One dimensional Green's function and Reciprocity theorem -Sturm-Liouville's type equation in one dimension & their Green's function.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. George Arfken and Hans J Weber, 2012, Mathematical Methods for Physicists – A Comprehensive Guide (7th edition), Academic press. 2. P.K. Chattopadhyay, 2013, *Mathematical Physics* (2^{nd} edition), New Age, New Delhi 3. A W Joshi, 2017, Matrices and Tensors in Physics, 4th Edition (Paperback), New Age International Pvt. Ltd., India 4. B. D. Gupta, 2009, *Mathematical Physics* (4^{th} edition), Vikas Publishing House, New Delhi. 5. H. K. Dass and Dr. Rama Verma, 2014, Mathematical Physics, Seventh Revised Edition, S. Chand & Company Pvt. Ltd., New Delhi.
REFERENCE BOOKS	1. E. Kreyszig, 1983, Advanced Engineering Mathematics, Wiley Eastern, New Delhi, 2. D. G. Zill and M. R. Cullen, 2006, Advanced Engineering Mathematics, 3rd Ed. Narosa, New Delhi. 3. S. Lipschutz, 1987, Linear Algebra, Schaum's Series, McGraw - Hill, New York 3. E. Butkov, 1968, Mathematical Physics Addison - Wesley, Reading, Massachusetts. 4. P. R. Halmos, 1965, Finite Dimensional Vector Spaces, 2nd Edition, Affiliated East West, New Delhi. 5. C. R. Wylie and L. C. Barrett, 1995, Advanced Engineering Mathematics, 6 th Edition, International Edition, McGraw-Hill, New York
WEB SOURCES	1. 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/

COURSEOUTCOMES:

At the endofthe course thestudentwillbeableto:

CO1	Understand use of bra-ket vector notation and explain the meaning of complete orthonormal set of basis vectors, and transformations and be able to apply them	**K1, K2**
CO2	Able to understand analytic functions, do complex integration, by applying Cauchy Integral Formula. Able to compute many real integrals and infinite sums via complex integration.	**K2, K3**
CO3	Analyze characteristics of matrices and its different types, and the process of diagonalization.	**K4**
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	**K4, K5**
CO5	To find the solutions for physical problems using linear differential equations and to solve boundary value problems using Green's function. Apply special functions in computation of solutions to real world problems	**K2, K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

MAPPINGWITHPROGRAMOUTCOMES:

Mapcourseoutcomes**(CO)**foreachcoursewithprogramoutcomes**(PO)**and program specific outcomes **(PSO)**inthe3-pointscaleofSTRONG(3),MEDIUM(2)andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	3

Paper-2 - CLASSICAL MECHANICS AND RELATIVITY	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	CLASSICAL MECHANICS AND RELATIVITY	Core				5	6	75

Pre-Requisites
Fundamentals of mechanics, Foundation in mathematical methods.
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. ➢ To learn the relativistic formulation of mechanics of a system.

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

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

TEXT BOOKS	1. H. Goldstein, *Classical Mechanics*, 3rd Edition, Pearson Edu. 2002. 2. J. C. Upadhyaya, *Classical Mechanics*, Himalaya Publshing Co. New Delhi. 3. S.L. Gupta,V.Kumar, H.V. Sharma, Classical Mechanics, PrakatiPrakashan, Meerut. 4. R. Resnick, *Introduction to Special Theory of Relativity*, Wiley Eastern, New Delhi, 1968. 5. N. C. Rana and P.S. Joag, Classical Mechanics - Tata McGraw Hill, 2001
REFERENCE BOOKS	1. R. G. Takwala and P.S. Puranik, Introduction to Classical Mechanics –Tata – McGraw Hill, New Delhi, 1980. 2. K. R. Symon, 1971, *Mechanics,* Addison Wesley, London. 3. S. N. Biswas, 1999, *Classical Mechanics*, Books & Allied, Kolkata. 4. T.W.B. Kibble, *Classical Mechanics*, ELBS. 5. Greenwood, *Classical Dynamics*, PHI, New Delhi.
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.	**K2**
CO2	Apply the principles of Lagrangianmechanics to solve the equations of motion of physical systems.	**K3**
CO3	Apply the principles of Hamiltonian mechanics to solve the equations of motion of physical systems.	**K3, K5**
CO4	Analyze the small oscillations in systems and determine their normal modes of oscillations.	**K4, K5**
CO5	Understand and apply the principles of relativistic kinematics to the mechanical systems.	**K2, K3**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	3	2	2
CO2	2	3	3	3	2	2	2	3	2	2
CO3	2	3	3	3	2	2	2	3	2	2
CO4	2	3	3	3	2	2	2	3	2	2
CO5	2	3	3	3	2	2	2	3	2	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	2

Paper- 3 - LINEAR AND DIGITAL ICs & APPLICATIONS	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	LINEAR AND DIGITAL ICs AND APPLICATIONS	Core				4	6	75

Pre-Requisites
Knowledge of semiconductor devices, basic concepts of digital and analog electronics
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 diagram, Op-Amp.Characteristics, DC and AC performance 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 andhigh pass filters, band pass, band reject and all pass 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 of PLL
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).
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. D. Roy Choudhury, Shail B. Jain (2012), Linear Integrated Circuit, 4th edition, New Age International Pvt.Ltd., NewDelhi,India. 2. Ramakant A. Gayakwad, (2012), OP-AMP and Linear Integrated Circuits, 4th edition, Prentice Hall / Pearson Education, NewDelhi. 3. B.L. Theraja and A.K. Theraja, 2004, A Textbook of Electrical technology, S. Chand & Co. 4. V.K. Mehta and Rohit Mehta, 2008, Principles of Electronics, S. Chand & Co, 12th Edition. 5. V. Vijayendran, 2008, Introduction to Integrated electronics (Digital & Analog), S.Viswanathan Printers & Publishers Private Ltd, Reprint. V.
REFERENCE BOOKS	1. Sergio Franco (1997), Design with operational amplifiers and analog integrated circuits, McGraw Hill, New Delhi. 2. Gray, Meyer (1995), Analysis and Design of Analog Integrated Circuits, Wiley International, New Delhi. 3. Malvino and Leach (2005), Digital Principles and Applications 5th Edition, Tata McGraw Hill, New Delhi 4. Floyd, Jain (2009), Digital Fundamentals, 8th edition, Pearson Education, New Delhi. 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, K5**
CO2	Develop skills to design linear and non-linear applications circuits using Op-Amp and design the active filters circuits.	**K3**
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.	**K1, K3**
CO4	Learn about various techniques to develop A/D and D/A converters.	**K2**
CO5	Acquire the knowledge about the CMOS logic, combinational and sequential circuits	**K1, K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	2	2	3	3	3	2
CO2	3	3	3	3	1	3	3	3	2	1
CO3	3	3	3	3	1	3	3	3	2	1
CO4	3	3	3	3	1	3	3	3	2	1
CO5	3	3	3	2	1	1	2	3	2	1

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	3	2	2	3	3	3	2
CO2	3	3	3	3	1	3	3	3	2	1
CO3	3	3	3	3	1	3	3	3	2	1
CO4	3	3	3	3	1	3	3	3	2	1
CO5	3	3	3	2	1	1	2	3	2	1

Discipline Centric Elective – I - PRACTICAL I	I YEAR - FIRST SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	PRACTICAL I	Core				3	6	50

Pre-Requisites

Knowledge and hands on experience of basic general and electronics experiments of Physics

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.

Course Details

PRACTICAL I
(Choose any SIX experiments from Part A and SIX from Part B)
PART A

1. Determination of Young's modulus and Poisson's ratio by Hyperbolic fringes - Cornu's Method
2. B-H loop using Anchor ring.
3. Determination of Thickness of the enamel coating on a wire by diffraction
4. Measurement of Band gap energy- Thermistor
5. Determination of Planck Constant – LED Method
6. Determination of Compressibility of a liquid using Ultrasonics
7. Determination of Wavelength, Separation of wavelengths - Michelson Interferometer
8. Measurement of Conductivity - Four probe method.
9. Arc spectrum – Iron.
10. Measurement of wavelength of Diode Laser / He – Ne Laser using Diffraction grating.
11. Determination of Diffraction pattern of light with circular aperture using Diode/He-Ne laser.
12. Measurement of Susceptibility of liquid - Quincke's method
13. UV-Visible spectroscopy – Verification of Beer-Lambert's law and identification of wavelength maxima – Extinction coefficient
14. Anderson's bridge – L_1,L_2,L_s,L_p

PART B

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

COURSE OUTCOMES:

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

CO1	Understand the strength of material using Young's modulus.	**K2**
CO2	Acquire knowledge of thermal behavior of the materials.	**K1**
CO3	Understand theoretical principles of magnetism through the experiments.	**K2**
CO4	Acquire knowledge about arc spectrum and applications of laser	**K1, K3**
CO5	Improve the analytical and observation ability in Physics Experiments	**K3, K5**
CO6	Conduct experiments on applications of FET and UJT	**K4**
CO7	Analyze various parameters related to operational amplifiers.	**K4**
CO8	Understand the concepts involved in arithmetic and logical circuits using IC's	**K2**
CO9	Acquire knowledge about Combinational Logic Circuits and Sequential Logic Circuits	**K1**
CO10	Analyze the applications of counters and registers	**K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	3	2	2	2	1	2	3
CO2	2	2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	2	2	2	2
CO6	2	2	2	3	3	1	1	1	3	3
CO7	2	2	3	3	3	1	1	1	3	3
CO8	3	3	3	3	3	3	2	2	3	3
CO9	3	3	3	3	3	3	1	1	1	1
CO10	3	3	3	3	3	3	1	1	1	1

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	2	2	2	3	2	2	2	1	2	3
CO2	2	2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	2	2	2	2
CO6	2	2	2	3	3	1	1	1	3	3
CO7	2	2	3	3	3	1	1	1	3	3
CO8	3	3	3	3	3	3	2	2	3	3
CO9	3	3	3	3	3	3	1	1	1	1
CO10	3	3	3	3	3	3	1	1	1	1

METHOD OF EVALUATION:

Continuous Internal Assessment	**End Semester Examination**	**Total**	**Grade**
50	50	**100**	

Paper 4 - STATISTICAL MECHANICS	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	STATISTICAL MECHANICS	Core				5	6	75

Pre-Requisites
Laws of thermodynamics, phase transition, entropy, ensembles, partition function, classical and quantum statistics, thermal equilibrium, Brownian motion
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: PHASE TRANSITIONS	Thermodynamic potentials - Phase Equilibrium - Gibb's phase rule - Phase transitions and Ehrenfest's classifications –Third law of Thermodynamics. Order parameters – Landau's theory of phase transition - Critical indices - Scale transformations and dimensional analysis.
UNIT II: STATISTICAL MECHANICS AND THERMODYNAMICS	Foundations of statistical mechanics - Specification of states of a system - Micro canonical ensemble - Phase space – Entropy - Connection between statistics and thermodynamics – Entropy of an ideal gas using the micro canonical ensemble - Entropy of mixing and Gibb's paradox.
UNIT III: CANONICAL AND GRAND CANONICAL ENSEMBLES	Trajectories and density of states - Liouville's theorem - Canonical and grand canonical ensembles - Partition function - Calculation of statistical quantities - Energy and density fluctuations.
UNIT IV: CLASSICAL AND QUANTUM STATISTICS	Density matrix - Statistics of ensembles - Statistics of indistinguishable particles - Maxwell-Boltzmann statistics - Fermi-Dirac statistics – Ideal Fermi gas – Degeneracy - Bose-Einstein statistics - Plank radiation formula - Ideal Bose gas - Bose-Einstein condensation.

UNIT V: LOW TEMPERATURE, ISING MODEL AND FLUCTUATIONS	Production of Low Temperature – Measurement of Low temperature - Ising model - Mean-field theories of the Ising model in two and one dimensions - Fluctuations and transport phenomena - Brownian motion - Langevin's theory - Fluctuation-dissipation theorem - The Fokker-Planck equation
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Dr. S. L. Gupta and Dr. V. Kumar, 2008, *ElementaryStatistical Mechanics,* 22nd Edition, PragatiPrakashan, Meerut. 2. S. K. Sinha, 1990, *Statistical Mechanics*, Tata McGraw Hill, New Delhi. 3. B. K. Agarwal and M. Eisner, 1998, *Statistical Mechanics,* Second Edition New Age International, New Delhi. 4. J. K. Bhattacharjee, 1996, *Statistical Mechanics*: An Introductory Text, Allied Publication, New Delhi. 5. F. Reif, 1965, *Fundamentals of Statistical and Thermal Physics,* McGraw -Hill, New York. 6. M. K. Zemansky, 1968, *Heat and Thermodynamics,* 5th edition, McGraw-Hill New York.
REFERENCE BOOKS	1. R. K. Pathria, 1996, *Statistical Mechanics,* 2nd edition, Butter WorthHeinemann, New Delhi. 2. L. D. Landau and E. M. Lifshitz, 1969, *Statistical Physics*, Pergamon Press, Oxford. 3. K. Huang, 2002, *Statistical Mechanics,* Taylor and Francis, London 4. W. Greiner, L. NeiseandH.Stoecker, *Thermodynamics and Statistical Mechanics,* Springer Verlang, New York. 5. A. B. Gupta, H. Roy, 2002, *Thermal Physics*, Books and Allied, Kolkata.
WEB SOURCES	1. https://byjus.com/chemistry/third-law-of-thermodynamics/ 2. https://web.stanford.edu/~peastman/statmech/thermodynamics.html 3. https://en.wikiversity.org/wiki/Statistical_mechanics_and_thermodynamics 4. https://en.wikipedia.org/wiki/Grand_canonical_ensemble 5. https://en.wikipedia.org/wiki/Ising_model

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	**K5**
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 behavior of the entropy by mixing two gases Justify the connection between statistics and thermodynamic quantities	**K4**
CO3	Differentiate between canonical and grand canonical ensembles and to interpret the relation between thermodynamical quantities and partition function	**K1**
CO4	To recall and apply the different statistical concepts to analyze the behavior of ideal Fermi gas and ideal Bose gas and also to compare and distinguish between the three types of statistics.	**K4, K5**
CO5	To discuss and examine the thermodynamicalbehavior of gases under fluctuation and also using Ising model	**K3**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	1	2	3	1	1	3
CO2	3	3	3	1	1	2	3	1	1	3
CO3	3	3	3	1	1	2	3	2	1	3
CO4	3	3	3	1	1	2	3	2	1	3
CO5	3	3	3	1	1	2	3	1	1	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	1	1	2	3	1	1	3
CO2	3	3	3	1	1	2	3	1	1	3
CO3	3	3	3	1	1	2	3	2	1	3
CO4	3	3	3	1	1	2	3	2	1	3
CO5	3	3	3	1	1	2	3	1	1	3

Paper 5 - QUANTUM MECHANICS – I	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	QUANTUM MECHANICS – I	Core				5	6	75

Pre-Requisites
Newton's laws of motion, Schrodinger's equation, integration, differentiation.
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	Wave Mechanical Concepts: Wave packet - Time dependent Schrodinger equation –Interpretation of the wave function –Ehrenfest's theorem- Time independent Schrodinger equation - Stationary states — Linear vector space – Linear operator – Eigen functions and Eigen Values – Hermitian Operator – Postulates of Quantum Mechanics – Simultaneous measurability of observables – General Uncertainty relation.
UNIT II: GENERAL FORMALISM	Dirac notation – Equations of motions – Schrodinger representation – Heisenberg representation – Interaction representation –Momentum representation – Symmetries and conservation laws: Conservation of linear momentum, Energy and Angular momentum – Parity conservation and time reversal.
UNIT III: ONE DIMENSIONAL AND THREE-DIMENSIONAL ENERGY EIGEN VALUE PROBLEMS	Square – well potential with rigid walls – Square well potential with finite walls – Square potential barrier – Alpha emission – Bloch waves in a periodic potential – Kronig-Penny square – well periodic potential – Linear harmonic oscillator: Operator method – Particle moving in a spherically symmetric potential – System of two interacting particles –Rigid rotator– Hydrogen atom.

UNIT IV: APPROXIMATION METHODS	Time independent perturbation theory:Non-degenerate energy levels – Ground state of Helium atom – First order Stark effect in Hydrogen atom – Degenerate energy levels - Excited state of Hydrogen atom - WKB approximation – Connection formulae (no derivation) –Application of WKB method: Barrier penetration – Alpha emission.
UNIT V: ANGULAR MOMENTUM	The Eigenvalue spectrum– Ladder operators– Matrix representation of J – Spin angular momentum – Addition of angular momenta – CG Coefficients – Angular momentum commutation relations – Eigen values of J^2 and J_z - Spin angular momentum - Pauli's exclusion principle.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2nd edition (37th Reprint), Tata McGraw-Hill, New Delhi, 2010. 2. G. Aruldhas, Quantum Mechanics, 2nd edition, Prentice Hall of India, New Delhi, 2009. 3. David J Griffiths, Introduction to Quantum Mechanics. 4th edition, Pearson, 2011. 4. SL Gupta and ID Gupta, Advanced Quantum Theory and Fields, 1st Edition, S.Chand& Co., New Delhi, 1982. 5. A. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, 4thEdition, Macmillan, India, 1984.
REFERENCE BOOKS	1. E. Merzbacher, Quantum Mechanics, 2nd Edition, John Wiley and Sons, New York, 1970. 2. V. K. Thankappan, Quantum Mechanics, 2nd Edition, Wiley Eastern Ltd, New Delhi, 1985. 3. L. D. Landau and E. M. Lifshitz, Quantum Mechanics, 1st edition, Pergomon Press, Oxford, 1976. 4. S. N. Biswas, Quantum Mechanics, Books and Allied Ltd., Kolkata,1999. 5. V. Devanathan, Quantum Mechanics, 2nd edition, Alpha Science International Ltd, Oxford , 2011.
WEB SOURCES	1. http://research.chem.psu.edu/lxjgroup/download_files/chem565-c7.pdf 2. http://www.feynmanlectures.caltech.edu/III_20.html 3. http://web.mit.edu/8.05/handouts/jaffe1.pdf 4. https://hepwww.pp.rl.ac.uk/users/haywood/Group_Theory_Lectures/Lecture_ 1.pdf 5. https://theory.physics.manchester.ac.uk/~xian/qm/chapter3.pdf

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, K5**
CO2	Is able to apply and analyze the Schrodinger equation to solve one dimensional problems and three dimensional problems	**K3, K4**
CO3	Can discuss the various representations, space time symmetries and formulations of time evolution	**K1**
CO4	Can formulate and analyze the approximation methods for various quantum mechanical problems	**K4, K5**
CO5	To apply non-commutative algebra for topics such as angular and spin angular momentum and hence explain spectral line splitting.	**K3, K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	S	3	2	2	3
CO3	2	3	3	2	3	2	3	2	2	3
CO4	3	3	3	3	3	2	3	3	2	3
CO5	3	3	3	2	3	S	3	3	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	S	3	2	2	3
CO3	2	3	3	2	3	2	3	2	2	3
CO4	3	3	3	3	3	2	3	3	2	3
CO5	3	3	3	2	3	S	3	3	2	3

Core Practical - PRACTICAL II	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	PRACTICAL II	Core				4	6	50

Pre-Requisites

Knowledge and handling of basic general and electronics experiments of Physics

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.
- To observe the applications of FET and UJT.
- To study the different applications of operational amplifier circuits.
- To learn about Combinational Logic Circuits and Sequential Logic Circuits

Course Details

PRACTICAL I

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

PART A

1. Determination of Young's modulus and Poisson's ratio by Elliptical fringes - Cornu's Method
2. Determination of Stefan's constant of radiation from a hot body
3. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.
4. B-H curve using CRO
5. Measurement of Magnetic Susceptibility - Guoy's method
6. Arc spectrum: Copper
7. Miscibility measurements using ultrasonic diffraction method
8. Determination of Thickness of thin film. - Michelson Interferometer
9. Determination of Refractive index of liquids using diode Laser/ He – Ne Laser
10. Determination of Numerical Apertures and Acceptance angle of optical fibers using Laser Source.
11. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility
12. Interpretation of vibrational spectra of a given material
13. Measurement of dielectric constant of liquids – LCR circuit.
14. Equipotential lines of different shapes.

PART B

1. Determination of I-V Characteristics and efficiency of solar cell.
2. IC 7490 as scalar and seven segment display using IC7447
3. Solving simultaneous equations – IC 741 / IC LM324
4. Op-Amp –Active filters: Low pass, High pass and Band pass filters (Second Order) Butter worth filter
5. Construction of Current to Voltage and Voltage to Current Conversion using IC 741
6. Realization of analog to digital converter (ADC) using 4-bit DAC and synchronous counter IC74193
7. Construction of square wave generator using IC 555 – Study of VCO
8. Construction of Schmidt trigger circuit using IC555 for a given hysteresis – Application as squarer
9. Construction of pulse generator using the IC 555 – Application as frequency divider
10. BCD to Excess- 3 and Excess 3 to BCD code conversion
11. Study of binary up / down counters - IC 7476 / IC7473
12. Shift register and Ring counter and Johnson counter- IC 7476/IC 7474
13. Construction of Multiplexer and Demultiplexer using ICs.
14. Construction of series voltage regulator.

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

METHOD OF EVALUATION:

Continuous Internal Assessment	End Semester Examination	Total	Grade
50	50	**100**	

COURSE OUTCOMES:

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

CO1	Understand the strength of material using Young's modulus	**K2**
CO2	Acquire knowledge of thermal behavior of the materials	**K1**
CO3	Understand theoretical principles of magnetism through the experiments.	**K2**
CO4	Acquire knowledge about arc spectrum and applications of laser	**K1**
CO5	Improve the analytical and observation ability in Physics Experiments	**K4**
CO6	Conduct experiments on applications of FET and UJT	**K5**
CO7	Analyze various parameters related to operational amplifiers	**K4**
CO8	Understand the concepts involved in arithmetic and logical circuits using IC's	**K2**
CO9	Acquire knowledge about Combinational Logic Circuits and Sequential Logic Circuits	**K3**
CO10	Analyze the applications of counters and registers	**K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	S	S	2	2	2	3	3
CO2	2	2	S	S	S	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3
CO6	2	2	2	3	3	2	2	2	3	3
CO7	2	2	3	3	3	2	2	3	3	3
CO8	3	3	3	3	3	3	3	3	3	3
CO9	3	3	3	3	3	3	3	3	3	3
CO10	3	3	3	3	3	3	3	3	3	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	2	2	2	3	3	2	2	2	3	3
CO2	2	2	3	3	3	2	2	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3
CO6	2	2	2	S	S	2	2	2	3	3
CO7	2	2	S	S	S	2	2	3	3	3
CO8	3	3	3	3	3	3	3	3	3	3
CO9	3	3	3	3	3	3	3	3	3	3
CO10	3	3	3	3	3	3	3	3	3	3

SEC 1–PHYSICS FOR COMPETITIVE EXAMINATIONS	I YEAR - SECOND SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	PHYSICS FOR COMPETITIVE EXAMINATIONS	SEC				2	4	75

Pre-Requisites
Newton's equations of motion, Black body radiation, Snell's law, Gauss' law, special theory of relativity etc.
Learning Objectives
➢ To develop the basics of physical principles and the mathematical background important to general mechanics and properties of matter. ➢ To recollect the ideas of heat and thermodynamics ➢ Formulation of the concepts of reflection, refraction in optics and longitudinal, transverse waves in sound. ➢ To explain the formalism of electricity and magnetism ➢ To discuss the concepts in modern physics.

UNITS	Course Details
UNIT I: GENERAL MECHANICS AND PROPERTIES OF MATTER	Physical quantities - SI system of units - dimensions - scalars and vectors (Concepts) - Newton's equations of motion - impulse - principle of conservation of linear momentum - projectile motion - Kepler's laws - Newton's law of gravitation - acceleration due to gravity - escape velocity - angular momentum - banking of roads - simple harmonic motion - viscosity - surface Tension.
UNIT II: HEAT AND THERMODYNAMICS	Different scales of temperatures - thermal expansions - calorimetry - specific heat - latent heat - triple point - transmission of heat - heat conductivity - Black body radiation - Stefan Boltzmann law - Wien's displacement law - Gas equation - Boyle's law - Charle's law - Law of equipartition of energy.
UNIT III: LIGHT AND SOUND	Reflection and refraction - Snell's law - total internal reflection - polarization - Brewster's Law - Huygen's principle – Young's double slit interference and single slit diffraction - longitudinal and transverse waves - velocity of sound - Newton's formula, Laplace correction, effects of pressure - beats - laws of vibrating strings - open and closed organ pipes - resonance.
UNIT IV: ELECTRICITY	Coulomb's Law - Electric field due to charged particles: a point charge, a dipole, a line of charge - electric flux - Gauss' law and applications – Biot-

AND MAGNETISM	Savart law, magnetic field due to a current in: a long straight wire, a circular arc of wire - Ampere's Law - magnetic field outside and inside a long straight wire - solenoids and toroids - Faraday's laws and Lenz's law
UNIT V: MODERN PHYSICS	Postulates of Einstein's theory of relativity - Galilean and Lorentz transformation - time dilation - length contraction - Planck's radiation - photoelectric effect - Compton shift, matter waves - Bohr's atomic theory. Nuclear properties - binding energy and mass defect -radioactive decay - alpha decay, beta decay and gamma decay - Radioactive dating.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. J. Walker, D. Halliday, R. Resnick, Fundamentals of Physics, 10th Edition, Wiley, United states of America, 2007. 2. H.C Verma, Concept of Physics, (Volume I), 1st Edition, Bharati Bhawan Publishers & Distributors, New Delhi, 2008. 3. H.C Verma, Concept of Physics, (Volume II), 1st Edition, Bharati Bhawan Publishers & Distributors, New Delhi, 2008.
REFERENCE BOOKS	1. Michael Nelkon, Philip Parker, Advanced Level Physics, 7th Edition, CBS Publishers, India, 1995 2. D. Young Hugh, A. Freedman Roger, University Physics with Modern Physics, 14th Edition, Pearson Education, India, 2017.
WEB SOURCE	1. https://hcverma.in/

COURSE OUTCOMES:

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

CO1	acquire the knowledge of the fundamental concept of physics	**K1**
CO2	understand the concepts of fundamental physics	**K2**
CO3	apply the concept of physics to solve various problems	**K3**
CO4	strengthen an appropriate problem-solving approach and assess a step to describe the quantitative analysis.	**K4**
CO5	evaluate the results of new analytical problems and develop a correct solutions or conclusions	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	2	2	2	2	3	2	2	3
CO2	3	3	2	2	3	2	3	2	2	3
CO3	3	3	2	2	3	2	3	2	2	3
CO4	3	3	2	2	3	2	3	3	2	3
CO5	3	3	2	2	3	2	3	3	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	2	2	1	1	2	3	2	2	3
CO2	3	2	2	2	3	2	3	2	2	3
CO3	2	3	3	2	1	2	3	2	2	3
CO4	1	3	3	2	1	2	3	3	2	3
CO5	1	3	3	2	1	2	3	3	2	3

Elective - List 1 – 1. ENERGY PHYSICS	I/II YEAR - FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ENERGY PHYSICS	ELECTIVE				3	4	75

Pre-Requisites
Knowledge of conventional energy resources
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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. G.D. Rai, 1996, Non – convention sources of, 4th edition, Khanna publishers, New Delhi. 2. S. Rao and Dr. ParuLekar, Energy technology. 3. M.P. Agarwal, Solar Energy, S. Chand and Co., New Delhi (1983). 4. Solar energy, principles of thermal collection and storage by S.P.Sukhatme, 2nd edition, Tata McGraw-Hill Publishing Co. Lt., New Delhi (1997). 5. Energy Technology by S.Rao and Dr.Parulekar.
REFERENCE BOOKS	1. Renewable energy resources, John Twidell and Tonyweir, Taylor and Francis group, London and New York. 2. Applied solar energy, A.B.MeinelandA.P.Meinal 3. John Twidell and Tony Weir, Renewable energy resources, Taylor and Francis group, London and New York. 4. Renewal Energy Technologies: A Practical Guide for Beginners C.S. Solanki-PHI Learning 5. Introduction to Non-Conventional Energy Resources -Raja et. al., Sci. Tech Publications
WEB 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	To identify various forms of renewable and non-renewable energy sources	**K1**
CO2	Understand the principle of utilizing the oceanic energy and apply it for practical applications.	**K2**
CO3	Discuss the working of a windmill and analyze the advantages of wind energy.	**K3**
CO4	Distinguish aerobic digestion process from anaerobic digestion.	**K3,K4**
CO5	Understand the components of solar radiation, their measurement and apply them to utilize solar energy.	**K2,K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	3	3	3
CO2	2	3	3	3	2	2	2	3	3	3
CO3	2	3	3	3	2	2	2	3	3	3
CO4	2	3	3	3	2	2	2	3	3	3
CO5	2	3	3	3	2	2	2	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	2	3	3	3	2	2	2	3	3	3
CO2	2	3	3	3	2	2	2	3	3	3
CO3	2	3	3	3	2	2	2	3	3	3
CO4	2	3	3	3	2	2	2	3	3	3
CO5	2	3	3	3	2	2	2	3	3	3

Elective - List 1 – 2. CRYSTAL GROWTH AND THIN FILMS	I/II YEAR – FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	CRYSTAL GROWTH AND THIN FILMS	ELECTIVE				3	4	75

Pre-Requisites
Fundamentals of Crystal Physics
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 of Thin Film Formation and thickness Measurement

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 Thomson - Gibbs - Types of Nucleation - Formation of critical Nucleus - Classical theory of Nucleation - Homo and heterogeneous formation of 3D nuclei - rate of Nucleation - Growth from vapour phase solutions, solutions and melts - epitaxial growth - Growth mechanism and classification - Kinetics of growth of epitaxial films
UNIT II: CRYSTALLIZATION PRINCIPLES	Crystallization Principles and Growth techniques Classes of Crystal system - Crystal symmetry - Solvents and solutions - Solubility diagram - Super solubility - expression for super saturation - Metastable zone and introduction period - Miers TC diagram - Solution growth - Low and high temperatures solution growth - Slow cooling and solvent evaporation methods - Constant temperature bath as a Crystallizer.
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 - Horizontal gradient freeze - Flux growth - Hydrothermal growth - Vapour phase growth - Physical vapour deposition - Chemical vapour deposition - Stoichiometry.

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: THIN FILM FORMATION	Thin Film Formation and thickness Measurement Nucleation, Film growth and structure - Various stages in Thin Film formation, Thermodynamics of Nucleation, Nucleation theories, Capillarity model and Atomistic model and their comparison. Structure of Thin Film, Roll of substrate, Roll of film thickness, Film thickness measurement - Interferometry, Ellipsometry, Micro balance, Quartz Crystal Oscillator techniques.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. V. Markov Crystal growth for beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy (2004) 2nd edition 2. A. Goswami, Thin Film Fundamentals (New Age, New Delhi, 2008) 3. M. Ohora and R. C. Reid, "Modeling of Crystal Growth Rates from Solution" 4. 4. D. Elwell and H. J. Scheel, "Crystal Growth from High Temperature Solution" 5. Heinz K. Henish, 1973, "Crystal Growth in Gels", Cambridge University Press. USA.
REFERENCE BOOKS	1. J.C. Brice, Crystal Growth Process (John Wiley, New York, 1986) 2. P. Ramasamy and F. D. Gnanam, 1983, "UGC Summer School Notes". 3. P. SanthanaRaghavan and P. Ramasamy, "Crystal Growth Processes",KRU Publications. 4. H.E. Buckley, 1951, Crystal Growth, John Wiley and Sons, New York 5. B.R. Pamplin, 1980, Crystal Growth, Pergman Press, London.
WEB SOURCES	1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRjLrXp3kMtrIO8kZl1D1Jp 2. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgwcy7KeTLUuBu3WF 3. https://www.youtube.com/playlist?list=PLADLRin7kNjG1Dlna9MDA53CMKFHPSi9m 4. https://www.youtube.com/playlist?list=PLXHedI-xbyr8xIl_KQFs_R_oky3Yd1Emw 5. https://www.electrical4u.com/thermal-conductivity-of-metals/

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**
CO2	Understand the Crystallization Principles and Growth techniques	**K2, K4**
CO3	Study various methods of Crystal growth techniques	**K3**
CO4	Understand the Thin film deposition methods	**K2**
CO5	Apply the techniques of Thin Film Formation and thickness Measurement	**K3, K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	1	2	1	3	2	2	2	2
CO2	3	3	1	3	1	2	3	2	2	1
CO3	3	2	1	3	1	2	3	3	3	1
CO4	3	2	1	2	1	2	3	3	3	1
CO5	2	3	3	3	1	3	3	3	3	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	2	1	2	1	3	2	2	2	2
CO2	3	3	1	3	1	2	3	2	2	1
CO3	3	2	1	3	1	2	3	3	3	1
CO4	3	2	1	2	1	2	3	3	3	1
CO5	2	3	3	3	1	3	3	3	3	2

Elective - List 1 – 3. ANALYSIS OF CRYSTAL STRUCTURES	I/II YEAR – FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ANALYSIS OF CRYSTAL STRUCTURES	ELECTIVE				3	4	75

Pre-Requisites
Fundamentals of crystal structures, symmetry and X-Ray Diffraction techniques
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, properties - sealed tube, rotating anode, synchrotron radiation - absorption - filters and monochromators Atomic scattering factor - Fourier transformation and structure factor - anomalous dispersion - Laue, rotation/oscillation, moving film methods- interpretation of diffraction patterns - cell parameter determination - systematic absences - space group determination.
UNIT III: STRUCTURE ANALYSIS	Single crystal diffractometers - geometries - scan modes - scintillation and area detectors -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 - conformational studies - computer program packages.
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 - high and low temperature and high pressure crystallography (basics only).
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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism.
TEXT BOOKS	1. Azaroff, L.V., "Elements of X-Ray Crystallography", Techbooksl, New York, 1992. 2. Blundell, T.L. and Johnson, L., "Protein Crystallography", Academic Press, New York, 1986. 3. Cullity, B.D. and Stock,S.R. "Elements of X-ray Diffraction", Pearson, 2014. 4. H.L. Bhat, Introduction to Crystal Growth Principles and Practice CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2015. 5. B.R. Pamplin, Crystal Growth, Pergamon Press, Oxford, 1975.
REFERENCE BOOKS	1. Glusker, J.P. and Trueblood, K.N. Crystal Structure Analysis: A Primer", Oxford University, Press, New York, 1994. 2. Ladd, M.F.C. and Palmer, R.A., "Structure Determination by X-ray Crystallography", Plenum Press, New York, 3rd Edition, 1993. 3. Stout, G.H. and Jensen, L."X-ray Structure Determination, A Practical Guide", Macmillan:,New York, 1989. 4. Woolfson, M.M. "An Introduction to X-ray Crystallography" Cambridge University Press, New York, 1997. 5. Sam Zhang, Lin Ki, Ashok Kumar, Materials Characterization Techniques, 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	**K2**
CO2	Gain a working knowledge of X-ray generation, X-ray photography with Laue, oscillation and moving film methods, and space group determination	**K1,K3**
CO3	Get an exposure to crystal structure determination using program packages	**K1,K4**
CO4	Understand the instrumentation used for powder diffraction, data collection, data interpretation, and structure refinement using Rietveld method	**K2, K4**
CO5	Get an insight into the structural aspects of proteins and nucleic acids, crystallization of proteins and methods to solve protein structures	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	2	1	2	2	2
CO2	3	3	3	2	2	2	1	2	2	2
CO3	3	3	2	2	2	2	2	2	2	2
CO4	3	2	2	2	2	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	2	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	3	2	1	2	2	2
CO2	3	3	3	2	2	2	1	2	2	2
CO3	3	3	2	2	2	2	2	2	2	2
CO4	3	2	2	2	2	2	2	2	2	2
CO5	3	2	2	2	2	2	2	2	2	2

Elective - List 1 – 4. MATERIALS SCIENCE	I/II YEAR - FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	MATERIALS SCIENCE	ELECTIVE				3	4	75

Pre-Requisites
➢ Basic knowledge on different types of materials
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 – charge injection, quasi-Fermi levels and recombination – optical absorption, loss and gain. Optical processes in quantum structures: Inter-band and intra-band transitions Organic semiconductors. Light propagation in materials – Electro-optic effect and modulation, electro-absorption modulation – exciton quenching.
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 – viscoelasticity – polymer processing techniques – 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 - nanomaterials: classification, size effect on structural and functional properties, processing and properties of Nano crystalline materials, single walled and multi walled carbon nanotubes

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Jasprit Singh, Electronic and optoelectronic properties of semiconductor structures, Cambridge University Press, 2007 2. P. K. Mallick. Fiber-Reinforced Composites. CRC Press, 2008. 3. V. Raghavan, 2003, Materials Science and Engineering, 4th Edition, Prentice- Hall India, New Delhi(For units 2,3,4 and 5) 4. G.K. Narula, K.S. Narula and V.K. Gupta, 1988, Materials Science, Tata McGraw-Hill 5. M. Arumugam, 2002, Materials Science, 3rd revised Edition, Anuratha Agencies
REFERENCE BOOKS	1. B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday. Textbook of Nanoscience and Nanotechnology. Springer- Verlag, 2012. 2. K. Yamauchi, I. Ohkata, K. Tsuchiya and S. Miyazaki (Eds). Shape Memory and Super Elastic Alloys: Technologies and Applications. Wood head Publishing Limited, 2011. 3. Lawrence H. VanVlack, 1998. Elements of Materials Science and Engineering, 6th Edition, Second ISE reprint, Addison-Wesley. 4. H. Iabch and H. Luth, 2002, Solid State Physics – An Introduction to Principles of Materials Science, 2nd Edition, Springer. 5. D. Hull & T. W. Clyne, An introduction to composite materials, Cambridge University Press, 2008.
WEB 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/ https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials_Science)/Electronic_Properties/Lattice_Vibrations

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

CO1	Acquire knowledge on optoelectronic materials	**K1**
CO2	Be able to prepare ceramic materials	**K3**
CO3	Be able to understand the processing and applications of polymeric materials	**K2, K3**
CO4	Be aware of the fabrication of composite materials	**K5**
CO5	Be knowledgeable of shape memory alloys, metallic glasses and nanomaterials	**K1**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	2	2	2	2	1	2	3
CO2	2	3	3	2	2	2	2	1	2	2
CO3	2	3	2	2	2	2	2	2	2	2
CO4	1	3	2	3	2	3	2	2	2	2
CO5	2	3	2	2	2	2	2	2	2	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	2	3	3	2	2	2	2	1	2	3
CO2	2	3	3	2	2	2	2	1	2	2
CO3	2	3	2	2	2	2	2	2	2	2
CO4	1	3	2	3	2	3	2	2	2	2
CO5	2	3	2	2	2	2	2	2	2	2

Elective - List 1 – 5. PHYSICS OF NANOSCIENCE AND TECHNOLOGY	I/II YEAR – FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	PHYSICS OF NANOSCIENCE AND TECHNOLOGY	ELECTIVE				3	4	75

Pre-Requisites
Basic knowledge in Solid State Physics
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.

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 - Mechanicalbehavior: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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. A textbook of Nanoscience and Nanotechnology, Pradeep T., Tata McGraw-Hill Publishing Co. (2012). 2. Principles of Nanoscience and Nanotechnology, M.A. Shah, Tokeer Ahmad, Narosa Publishing House Pvt Ltd., (2010). 3. Introduction to Nanoscience and Nanotechnology, K. K. Chattopadhyay and A.N. Banerjee, PHI Learning Pvt. Ltd., New Delhi, (2012). 4. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press, (2002). 5. Nanotechnology and Nanoelectronics, D.P. Kothari, V. Velmurugan and Rajit Ram Singh, Narosa Publishing House Pvt.Ltd, New Delhi. (2018)
REFERENCE BOOKS	1. Nanostructures and Nanomaterials – HuozhongGao – Imperial College Press (2004). 2. Richard Booker and Earl Boysen, (2005) Nanotechnology, Wiley Publishing Inc. USA 3. Nano particles and Nano structured films; Preparation, Characterization and Applications, J.H.Fendler John Wiley and Sons. (2007) 4. Textbook of Nanoscience and Nanotechnology, B.S.Murty, et al., Universities Press. (2012) 5. The Nanoscope (Encyclopedia of Nanoscience and Nanotechnology), Dr. Parag Diwan and Ashish Bharadwaj (2005) Vol. IV - Nanoelectronics Pentagon Press, New Delhi.
WEB 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**
CO2	Explore various physical, mechanical, optical, electrical and magnetic properties nanomaterials.	**K1**
CO3	Understand the process and mechanism of synthesis and fabrication of nanomaterials.	**K2, K3**
CO4	Analyze the various characterization of Nano-products through diffraction, spectroscopic, microscopic and other techniques.	**K4**
CO5	Apply the concepts of nanoscience and technology in the field of sensors, robotics, purification of air and water and in the energy devices.	**K3**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	1	1	3	3	3	3
CO2	3	3	3	2	1	1	3	3	3	3
CO3	3	3	2	2	1	1	3	3	3	3
CO4	3	3	3	2	1	1	3	3	3	3
CO5	3	3	2	2	1	1	3	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	1	1	3	3	3	3
CO2	3	3	3	2	1	1	3	3	3	3
CO3	3	3	2	2	1	1	3	3	3	3
CO4	3	3	3	2	1	1	3	3	3	3
CO5	3	3	2	2	1	1	3	3	3	3

Elective - List 1 – 6. DIGITAL COMMUNICATION	I/II YEAR - FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	DIGITAL COMMUNICATION	ELECTIVE				3	4	75

Pre-Requisites
Exposure to Fourier transform, pulse modulation, multiplexing, noises in communication signals
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
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. B.P. Lathi, *Communication system*, Wiley Eastern. 2. George Kennedy, *Electronic Communication Systems*, 3rd Edition, Mc Graw Hill. 3. Simon Haykin, *Communication System*, 3rd Edition, John Wiley & Sons. 4. George Kennedy and Davis, 1988, *Electronic Communication System*, Tata McGraw Hill 4th Edition. 5. Taub and Schilling, 1991, *"Principles of Communication System"*, Second edition Tata McGraw Hill.
REFERENCE BOOKS	1. John Proakis, 1995, *Digital Communication*, 3rd Edition, McGraw Hill, Malaysia. 2. M. K. Simen, 1999, *Digital Communication Techniques, Signal Design and Detection*, Prentice Hall of India. 3. Dennis Roddy and Coolen, 1995, *Electronics communications*,Prentice Hall of India IV Edition. 4. Wave Tomasi, 1998, *"Advanced Electronics communication System"* 4th Edition Prentice Hall, Inc. 5. M.Kulkarni, 1988, *"Microwave and Radar Engineering"*, Umesh Publications.
WEB 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, K3**
CO2	Apply different information theories in the process of study of coding of information, storage and communication	**K3**
CO3	Explain and compare the various methods of pulse modulation techniques	**K4**
CO4	Apply the error control coding techniques in detecting and correcting errors- able to discuss, analyze and compare the different error control coding	**K3, K4**
CO5	Apply, discuss and compare the spread spectrum techniques for secure communications	**K3, k5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	2	2	3	2	2	3
CO2	3	3	3	1	2	2	3	2	2	3
CO3	3	3	3	1	2	2	3	2	2	3
CO4	3	3	3	1	2	2	3	2	2	3
CO5	3	3	3	1	2	2	3	2	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	1	2	2	3	2	2	3
CO2	3	3	3	1	2	2	3	2	2	3
CO3	3	3	3	1	2	2	3	2	2	3
CO4	3	3	3	1	2	2	3	2	2	3
CO5	3	3	3	1	2	2	3	2	2	3

Elective List 1 – 7. COMMUNICATION ELECTRONICS	I/II YEAR – FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	COMMUNICATION ELECTRONICS	ELECTIVE				3	4	75

Pre-Requisites
Knowledge of Regions of electromagnetic spectrum and its characteristics
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-groundedantenna-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—multicavity Klystron-reflex klystron-magnetrontravelling wave tubes (TWT) and other microwave tubes-MASER-Gunndiode-wave guides-rectangular wave guides-standing wave indicator andstanding wave ratio(SWR)
UNIT III: RADAR AND TELEVISION	Elements of a radar system-radar equation-radar performance Factorsradar transmitting systems-radar antennas-duplexers-radarreceivers and indicators-pulsed systems-other radar systems-colourTVtransmission and reception-colour mixing principle-colour picture tubes-Delta gun picture tube-PIL colour picture tube-cable TV, CCTV andtheatre TV
UNIT IV: OPTICAL FIBER	Propagation of light in an optical fibre-acceptance angle-numericalaperture-step and graded index fibres-optical fibres as a cylindrical waveguide-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 systemlink models-satellite system parameters-satellite system link equationlinkbudget-INSAT communication satellites

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Handbook of Electronics by Gupta and Kumar, 2008 edition. 2. Electronic communication systems – George Kennedy and Davis, Tata McGraw Hill, 4th edition, 1988. 3. Taub and Schilling, principles of communication systems, second edition, Tata Mc Graw Hill (1991). 4. M. Kulkarani, Microwave and radar engineering, UmeshPublications, 1998. 5. Mono Chrome and colour television, R. R. Ghulathi
REFERENCE BOOKS	1. Electronic communications – Dennis Roody and Coolen, Prentice Hall of India, IV edition, 1995. 2. Wayne Tomasi, Advanced electronics communication systems, fourth edition, Prentice Hall of India, 1998 3. Dennis Roddy and Coolen,1995,*Electronicscommunications*,Prentice Hall of India IV Edition. 4. Wayne Tomasi,1998 *"Advanced Electronics communication System"* 4thedition, Prentice Hall of India, 1998 5. S. Salivahanan, N. Suersh Kumar & A. Vallavaraj, 2009, Electronic Devices and Circuits, Tata McGraw-Hill Publishing Company Limited, New Delhi, Second Edition.
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, K5**
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	**K4**
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	**K3**
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	**K1, K3**
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	**K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	2	2	3	2	1	3
CO2	3	3	3	1	2	2	3	2	1	3
CO3	3	3	3	1	2	2	3	2	1	3
CO4	3	3	3	1	2	2	3	2	1	3
CO5	3	3	3	1	2	2	3	2	1	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	1	2	2	3	2	1	3
CO2	3	3	3	1	2	2	3	2	1	3
CO3	3	3	3	1	2	2	3	2	1	3
CO4	3	3	3	1	2	2	3	2	1	3
CO5	3	3	3	1	2	2	3	2	1	3

Elective List 1 – 8.ASTROPHYSICS	I/II YEAR – FIRST/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ASTROPHYSICS	ELECTIVE				3	4	75

Pre-Requisites
Fundamental knowledge about electromagnetic spectrum, wave nature of light and about the universe and the galaxy where we live in.
Learning Objectives
➢ To impart knowledge on the physical universe and its evolution. ➢ To make the student to understand fundamental principles and techniques of astronomy and astrophysics. ➢ To make the student to study electromagnetic radiation from stars, atomic spectra and classification of stars. ➢ To provide information about the properties and the evolution of stars. ➢ To render information about astronomical instrumentation.

UNITS	Course Details
UNIT I: OBSERVATIONAL ASTRONOMY	The electromagnetic spectrum; geometrical optics (ray diagrams, focal length, magnification etc); diffraction (resolving power, Airy disc, diffraction limit etc); telescopes (reflecting, refracting, multiwavelength)
UNIT II: PROPERTIES OF STARS	Brightness (luminosities, fluxes and magnitudes); colours (black body radiation, the Planck, Stefan-Boltzmann and Wien's laws, effective temperature, interstellar reddening); spectral types; spectral lines (Bohr model, Lyman & Balmer series etc, Doppler effect); Hertzprung-Russell diagram; the main sequence (stellar masses ,binary systems, Kepler's laws, mass-luminosity relations); distances to stars (parallax, standard candles, P-L relationships, ms-fitting etc); positions of stars (celestial sphere, coordinate systems, proper motions, sidereal and universal time).
UNIT III: THE LIFE AND DEATH OF STARS	Energy source (nuclear fusion, p-pchain, triple-alpha, CNO cycle, lifetime of the Sun); solar neutrinos; basic stellar structure hydro static equilibrium, equation of state);evolution beyond the main sequence; formation of the heavy elements; supernovae; stellar remnants(white dwarfs, neutron stars, black holes, degeneracy pressure, Swarszchild radius, escape velocities).
UNIT IV: GALAXIES	Constituents of galaxies; stellar populations; the interstellar medium; HII regions; 21cm line; spirals and ellipticals; galactic dynamics; galaxy rotation curves and dark matter ; active galaxies and quasars.

UNIT V: COSMOLOGY	Galaxies and the expanding Universe; Hubble's Law; the age of the Universe; the Big Bang; cosmic microwave background (black body radiation);big bang nucleosynthesis (cosmic abundances, binding energies, matter & radiation); introductory cosmology (the cosmological principle, homogeneity and isotropy, Olber's paradox); cosmological models (critical density, geometry of space, the fate of the Universe); dark energy and the accelerating Universe.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1.Zeilik& Gregory, Introductory Astronomy & Astrophysics,4thedition (Saunders College Publishing) 2.Morison,I.,IntroductiontoAstronomyand Cosmology, (Wiley) 3.Kutner,M.L., Astronomy: A Physical Perspective (Cambridge University Press) 4. Green,S.F.&Jones,M.H.,An Introduction to the Sunand Stars (Cambridge University Press)
REFERENCE BOOKS	5.Jones,M.H.&Lambourne,R.J.A.,An Introduction to Galaxies & Cosmology (Cambridge UniversityPress) 6.Carroll,B.W.&Ostlie,D.A.,An Introduction to ModernAstrophysics (Pearson) 7.Shu,F.H.,The Physical Universe, An Introduction to Astronomy, (University Science Books) 8.Motz,L.&Duveen,A.,The Essentials of Astronomy, (ColombiaUniversityPress)
WEB SOURCES	1. https://www.coursera.org/courses?query=astrophysics 2. https://www.space.com 3. https://www.britanica.com 4. https://science.nasa.gov 5. https://merriam-webster.com

COURSE OUTCOMES:

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

CO1	Recall and understand the electromagnetic ration from celestial objects. Analyze the wave nature of light in the form of ray diagram. Apply the knowledge of phenomenon of diffraction and asses, how diffraction limits the resolution of any system having a lens or mirror. Distinguish between reflecting and refracting telescopes and their usage.	**K1 K2 K3 K4 K5**
CO2	Correlate luminosity, flux and magnitude, related to the brightness of a star. Analyze the evolution of stars using HR diagram. Apply and examine the various laws related to temperature of a star. Assess the distance of stars, measured using trigonometric parallax method. Understand the position of star in the celestial sphere. Distinguish between sideral and universal time.	**K1 K2 K3 K4 K5**
CO3	Define nuclear fusion, which is the fundamental energy source of stars. Analyze, how neutrinos are born during the process of nuclear fusion in the sun. Recall and explain the CNO cycle – the main source of energy of hotter stars. Comprehend stellar evolution, including red giants, supernovas, neutron stars, pulsars, white dwarfs and black holes, using evidence and presently accepted theories	**K1 K2 K3 K4**
CO4	Remember and illustrate the structure of our Milky way galaxy. Classify the types of galaxies. Understand thepresence of dark matter in the universe. Explain, howquasars and active galaxies are powered by supermassiveblack holes which produce copious luminosity.	**K1 K2 K3 K4**
CO5	Explain cosmology, a branch of astronomy that involvesthe origin and evolution of the universe, from the Big Bangto today and on into the future. Define Hubble's law ofcosmic expansion. Analyze and assess the big bangnucleosynthesis universe that explains the relative	**K1 K2 K3 K4 K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	1	2	1	3	2	1	2
CO2	3	2	3	1	2	1	3	2	1	2
CO3	3	2	3	1	2	1	3	2	1	2
CO4	3	2	3	1	2	1	3	2	1	2
CO5	3	2	3	1	2	1	3	2	1	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	2	3	1	2	1	3	2	1	2
CO2	3	2	3	1	2	1	3	2	1	2
CO3	3	2	3	1	2	1	3	2	1	2
CO4	3	2	3	1	2	1	3	2	1	2
CO5	3	2	3	1	2	1	3	2	1	2

Elective - List 2 – 9. PLASMA PHYSICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	PLASMA PHYSICS	ELECTIVE				3	4	75

Pre-Requisites
Fundamentals of Electricity and Magnetism, Electromagnetic theory, Maxwell's equation, Basic knowledge of electrical and electronics instrumentation.
Learning Objectives
➢ To explore the plasma universe by means of in-site and ground-based observations. ➢ To understand the model plasma phenomena in the universe. ➢ 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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Plasma Physics- Plasma State of Matter - S. N.Sen, PragatiPrakashan, Meerut. 2. Introduction to Plasma Physics-M. Uman 3. Krall, N. A., and A. W. Trivelpiece. Principles of Plasma Physics. Berkeley, CA: San Francisco Press, 1986. ISBN: 9780911302585.Tanenbaum, B. S. Plasma Physics. New York, NY: McGraw-Hill, 1967. ISBN: 9780070628120. 4. Goldston, R. J., and P. H. Rutherford. Introduction to Plasma Physics. Philadelphia, PA: IOP Publishing, 1995. ISBN: 9780750301831. 5. Hutchinson, I. H. Principles of Plasma Diagnostics. Cambridge, UK: Cambridge University Press, 2005. ISBN: 9780521675741.
REFERENCE BOOKS	1. Chen, F. F. Introduction to Plasma Physics. 2nd ed. New York, NY: Springer, 1984. ISBN: 9780306413322. 2. Introduction to Plasma Theory-D.R. Nicholson 3. Shohet, J. L. The Plasma State. San Diego, CA: Academic Press Inc., 1971. ISBN: 9780126405507. 4. Hazeltine, R. D., and F. L. Waelbroeck. The Framework of Plasma Physics. Boulder, CO: Westview Press, 2004. ISBN: 9780813342139. 5. Huddlestone, R. H., and S. L. Leonard. Plasma Diagnostic Techniques. San Diego, CA: Academic Press, 1965
WEB SOURCES	1. https://fusedweb.llnl.gov/Glossary/glossary.html 2. http://farside.ph.utexas.edu/teaching/plasma/lectures1/index.html 3. http://www.plasmas.org/ 4. http://www.phy6.org/Education/whplasma.html 5. http://www.plasmas.org/resources.htm

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**
CO2	Understand the plasma and learn the magneto-hydrodynamics concepts applied to plasma.	**K2**
CO3	Explore the oscillations and waves of charged particles and thereby apply the Maxwell's equation to quantitative analysis of plasma.	**K1, K3**
CO4	Analyze the different principle and techniques to diagnostics of plasma.	**K2, K5**
CO5	Learn the possible applications of plasma by incorporating various electrical and electronic instruments.	**K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	2	1	1	2	1	2	3	3
CO2	3	3	2	1	1	2	1	2	3	3
CO3	3	3	2	2	1	2	1	3	3	3
CO4	3	3	3	2	1	2	1	3	3	3
CO5	3	3	3	2	1	2	1	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	2	1	1	2	1	2	3	3
CO2	3	3	2	1	1	2	1	2	3	3
CO3	3	3	2	2	1	2	1	3	3	3
CO4	3	3	3	2	1	2	1	3	3	3
CO5	3	3	3	2	1	2	1	3	3	3

Elective - List 2 – 10. BIO PHYSICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	BIO PHYSICS	ELECTIVE				3	4	75

Pre-Requisites
Fundamental concepts of Physicsand Biology
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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. 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 by Daniel A Beard (Cambridge University Press, 2008). 2. Essential cell biology by Bruce Albert et al (Garland Science) 3. Biophysics, W. Hoppe, W. Lohmann, H. Markl and H. Ziegler. Springer Verlag, Berlin (1983). 4. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A. Tuszynski, (Springer science & business media). 5. Biological spectroscopyby 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.	**K2, K3**
CO2	Comprehension of the role of biomolecular conformation to function.	**K1**
CO3	Conceptual understanding of the function of biological membranes and also to understand the functioning of nervous system.	**K2, K5**
CO4	To know the effects of various radiations on living systems and how to prevent ill effects of radiations.	**K1, K5**
CO5	Analyze and interpret data from various techniques viz., spectroscopy, crystallography, chromatography etc.,	**K4**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	1	2	1	3	3	2
CO2	3	3	3	2	1	2	1	3	3	2
CO3	3	3	3	3	1	1	2	3	3	2
CO4	3	3	3	2	1	1	2	3	3	3
CO5	3	3	3	3	1	1	2	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	1	2	1	3	3	2
CO2	3	3	3	2	1	2	1	3	3	2
CO3	3	3	3	3	1	1	2	3	3	2
CO4	3	3	3	2	1	1	2	3	3	3
CO5	3	3	3	3	1	1	2	3	3	3

Elective List 2 – 11. NONLINEAR DYNAMICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	NONLINEAR DYNAMICS	ELECTIVE				3	4	75

Pre-Requisites
Basics of Numerical methods and Differential equations, Fundamentals of linear and nonlinear waves, and Basics of communication systems
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: 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 Dinamical system – Strange attractors – Routes to chaos.
UNIT IV: DUFFING OSCILLATOR AND FRACTALS	**Bifurcation scenario in Duffing Oscillator-Period doubling route to chaos-Intermittency transition-Fractals-Fractal dimension-Properties of fractal-Construction and properties of middle third contor set and Koch curve-Application of fractals.**
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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. M.Lakshmanan and S.Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns.Springer, 2003. 2. A.Hasegawa and Y.Kodama, Solitons in Optical Communications. Oxford Press, 1995. 3. Drazin, P. G. Nonlinear Systems. Cambridge University Press, 2012. ISBN: 9781139172455. 4. Wiggins, S. Introduction to Applied Nonlinear Dynamical Systems and Chaos. Springer, 2003. ISBN: 9780387001777. 5. Strogatz, Steven H. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014. ISBN: 9780813349107.
REFERENCE BOOKS	1. G.Drazin and R.S.Johnson. Solitons: An Introduction. Cambridge University Press, 1989. 2. M.Lakshmanan and K.Murali. Chaos in Nonlinear Oscillators. World Scientific, 1989. 3. S.Strogatz**.** Nonlinear Dynamics and Chaos. Addison Wesley, 1995. 4. Hao Bai-Lin, Chaos (World Scientidic, Singapore, 1984). 5. Kahn, P. B., Mathematical Methods for Scientists & Engineers (Wiley, NY, 1990)
WEB 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, K4**
CO2	Understand the concepts of different types of coherent structures and their importance in science and technology.	**K2**
CO3	Learn about simple and complex bifurcations and the routes to chaos	**K1, K2**
CO4	Acquire knowledge about various oscillators, characterization of chaos and fractals.	**K1**
CO5	To analyze and evaluate the applications of solutions in telecommunication, applications of chaos in cryptography, computations and that of fractals.	**K3, K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	2	1	2	2	2	2
CO2	3	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	1	2	2	2	2
CO5	1	2	2	2	2	2	2	2	2	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	2	1	2	2	2	2
CO2	3	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	1	2	2	2	2
CO5	1	2	2	2	2	2	2	2	2	2

Elective - List 2 – 12. QUANTUM FIELD THEORY	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	QUANTUM FIELD THEORY	ELECTIVE				3	4	75

Pre-Requisites
Prior exposure on fundamentals of Quantum mechanics and Special Relativity will be essential.
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 LagrangianandHamiltonian, Noether's theorem and derivation of energy-momentum and angular momentum tensors as consequence of Poincarésymmetry, 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 eigenstates 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.

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

TEXT BOOKS	1. J. D. BjorkenandS. D. Drell,RelativisticQuantum FieldsDavid 2. An Introduction to Quantum Field Theory by M. Peskin and D. V. Schroeder 3. Quantum Field theory: From Operators to Path Integrals, 2nd edition by Kerson Huang 4. Quantum Field Theory by Mark Srednicki 5. Quantum Field Theory by Claude Itzykson and Jean Bernard Zuber.
REFERENCE BOOKS	1. V.B. Berestetskii,E.M.LifshitzandL.P.Pitaevskii,*QuantumElectrodynamics* 2. Introduction to the Theory of Quantized Fields by N. N. Bogoliubov and D. V. Shirkov (1959) 3. Quantum Field Theory by L. H. Ryder (1984) 4. Quantum Field Theory by L. S. Brown (1992) 5. Quantum Field Theory: A Modern Introduction by M. Kaku (1993)
WEB 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**
CO2	Enable the students to understand the method of quantization to various field	**K2**
CO3	Employ the creation and annihilation operators for quantization	**K5**
CO4	Summarizes the interacting field, in quantum domain, and gives a discussion on how perturbation theory is used here.	**K1, K3**
CO5	Understand the concept of Feynman diagram	**K2**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	2	3	3	3	3	2	3
CO3	3	3	3	2	3	2	3	3	2	3
CO4	3	3	3	2	3	3	3	3	2	3
CO5	3	3	3	2	3	3	3	3	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	3	2	3	3	2	3
CO2	3	3	3	2	3	3	3	3	2	3
CO3	3	3	3	2	3	2	3	3	2	3
CO4	3	3	3	2	3	3	3	3	2	3
CO5	3	3	3	2	3	3	3	3	2	3

Elective - List 2 – 13. GENERAL RELATIVITY AND COSMOLOGY	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	GENERAL RELATIVITY AND COSMOLOGY	ELECTIVE				3	4	75

Pre-Requisites
Skill in mathematics and mechanics
Learning Objectives
➢ To give an introduction to students in the areas of general relativity and cosmology

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 spacetime 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

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

TEXT BOOKS	1. M. R. Spiegel, *Vector Analysis, Schaum'a outline series*, McGraw Hill, New York, 1974. 2. James Hartle, *Gravity: An introduction to Einstein's general relativity*, San Francisco, Addison-Wesley, 2002 3. Sean Carroll, *Spacetime and Geometry: An Introduction to General Relativity*, (Addison-Wesley, 2004). 4. Jerzy Plebanskiand Andrzej Krasinski, *An Introduction to General Relativity and Cosmology*, Cambridge University Press 2006 5. Meisner, Thorne and Wheeler: *Gravitation* W. H. Freeman & Co., San Francisco 1973
REFERENCE BOOKS	1. Robert M. Wald: *Space, Time, and Gravity: the Theory of the Big Bang and Black Holes*, Univ. of Chicago Press. 2. J. V. Narlikar, *Introduction to Cosmology*, Jones &Bartlett 1983 3. Steven Weinberg, *Gravitation and Cosmology*, New York, Wiley, 1972. 4. Jerzy Plebanski and Andrzej Krasinski, *An Introduction to General Relativity and Cosmology*, Cambridge University Press 2006 5. R Adler, M Bazin& M Schiffer, *Introduction to General Relativity*
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**
CO2	Understanding of the underlying theoretical aspects of general relativity and cosmology	**K2**
CO3	Gain knowledge on space time curvature	**K1**
CO4	Equipped to take up research in cosmology	**K3, K4**
CO5	Confidently solve problems using mathematical skills	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) and LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	1	3	2	3	2	2	2	2
CO2	3	3	1	3	2	3	2	2	2	2
CO3	3	2	1	2	1	2	1	1	3	2
CO4	3	2	1	2	1	2	1	1	3	2
CO5	3	2	1	2	1	2	1	1	3	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	1	3	2	3	2	2	2	2
CO2	3	3	1	3	2	3	2	2	2	2
CO3	3	2	1	2	1	2	1	1	3	2
CO4	3	2	1	2	1	2	1	1	3	2
CO5	3	2	1	2	1	2	1	1	3	2

Elective - List 2 – 14. ADVANCED OPTICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ADVANCED OPTICS	ELECTIVE				3	4	75

Pre-Requisites
Knowledge of ray properties and wave nature of light
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 – Ruby laser – Nd:YAG laser – gas lasers – He-Ne laser – CO_2 laser – Chemical lasers – HCl 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 – Voigt effect – Cotton-mouton effect – Kerr magneto-optic effect – Electro-optical effects – Stark effect – Inverse stark effect – Electric double refraction – Kerr electro-optic effect – Pockels electro-optic effect
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. B. B. Laud, 2017, Lasers and Non – Linear Optics, 3rd Edition, New Age International (P) Ltd. 2. AjoyGhatak, 2017, Optics, 6th Edition, McGraw – Hill Education Pvt. Ltd. 3. William T. Silfvast, 1996, Laser Fundamentals Cambridge University Press, New York 4. J. Peatros, Physics of Light and Optics, a good (and free!) electronic book 5. B. Saleh, and M. Teich, Fundamentals of Photonics, Wiley-Interscience,
REFERENCE BOOKS	1. F. S. Jenkins and H. E. White, 1981, Fundamentals of Optics, (4th Edition), McGraw – Hill International Edition. 2. Dieter Meschede, 2004, Optics, Light and Lasers, Wiley – VCH, Varley GmbH. 3. Lipson, S. G. Lipson and H. Lipson, 2011, Optical Physics, 4th Edition, Cambridge University Press, New Delhi, 2011. 4. Y. B. Band, Light and Matter, Wiley and Sons (2006) 5. R. Guenther, Modern Optics, Wiley and Sons (1990)
WEB 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**
CO2	Discriminate all the fundamental processes involved in laser devices and to analyze the design and operation of the devices	**K2**
CO3	Demonstrate the basic configuration of a fiber optic – communication system and advantages	**K3, K4**
CO4	Identify the properties of nonlinear interactions of light and matter	**K4**
CO5	Interpret the group of experiments which depend for their action on an applied magnetics and electric field	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	3	3	3	3	3
C02	3	3	3	2	3	3	3	3	3	3
CO3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	3	3	3	3	3	3
CO2	3	3	3	2	3	3	3	3	3	3
CO3	3	3	3	2	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3

Elective - List 2 – 15. ADVANCEDMATHEMATICAL PHYSICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ADVANCEDMATHEMATICAL PHYSICS	ELECTIVE				3	4	75

Pre-Requisites
Good knowledge in basic mathematics
Learning Objectives
➢ To educate and involve students in the higher level of mathematics and mathematical methods relevant and applicable to Physics.

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.

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. A.W.Joshi, Group Theory for Physicists 2. D.B.Lichtenberg, Unitary Symmetry and Elementary Particles 3. E.Butkov, Mathematical Physics 4. J.V.Narlikar, General Relativity & Cosmology 5. R. Geroch, Mathematical Physics, The University of Chicago press (1985).
REFERENCE BOOKS	1. M.Hamermesh ***Group Theory*** 2. M.E.Rose: Elementary Theory of Angular Momentum 3. Georgi : Lie Groups for Physicists 4. E.A.Lord: Tensors, Relativity & Cosmology 5. P. Szekeres, A course in modern mathematical physics: Groups, Hilbert spaces and differential geometry, Cambridge University Press.
WEB 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 to:

CO1	Gained knowledge of both discrete and continuous groups	**K1**
CO2	Apply various important theorems in group theory	**K3**
CO3	Construct group multiplication table, character table relevant to important branches of physics.	**K5**
CO4	Equipped to solve problems in tensors	**K4, K5**
CO5	Developed skills to apply group theory and tensors to peruse research	**K2, K3**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	2	1	1	2	1	2	3	3
CO2	3	3	2	1	1	1	1	2	3	2
CO3	3	3	2	1	2	2	1	2	3	2
CO4	3	3	2	2	1	2	1	2	3	2
CO5	3	3	2	2	2	1	1	2	3	2

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	3	3	2	1	1	2	1	2	3	3
CO2	3	3	2	1	1	1	1	2	3	2
CO3	3	3	2	1	2	2	1	2	3	2
CO4	3	3	2	2	1	2	1	2	3	2
CO5	3	3	2	2	2	1	1	2	3	2

Elective - List 3 – 16. ADVANCED SPECTROSCOPY	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	ADVANCED SPECTROSCOPY	ELECTIVE				3	4	75

Pre-Requisites
Basic knowledge of group theory, abstract thinking ability, lasers, chemical bonds and molecular structures
Learning Objectives
➢ Helps students understand and appreciate spectroscopy as a sufficiently broad field in which many sub disciplines exist. ➢ Make them appreciate each of these specific techniques with numerous implementations. ➢ To realize the progress in this field that is rapid, resulting in improved instrument capabilities and an ever-widening range of applications. ➢ To apply group theory in spectroscopy to shed light on molecular symmetry and determine important physical parameters.

UNITS	CourseDetails
UNITI: 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
UNITII: 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
UNITIII: 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
UNITIV: 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

UNITV: MOLECULAR MODELLING	Determination of force constants- force field from spectroscopic data- normal coordinate analysis of a simple molecule (H2O) – analyzing thermodynamic functions, partition functions, enthalpy, specific heat and related parameters from spectroscopic data- molecular modelling using data from various spectroscopic studies
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. William Kemp, 2019, Organic Spectroscopy (2nd Edition) MacMillan, Indian Edition. 2. C N Banwell and McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw–Hill, New Delhi. 3. D.N. Satyanarayana, 2001, *Vibrational Spectroscopy and Applications*, New Age International Publication. 4. B.K. Sharma , 2015, *Spectroscopy*, Goel Publishing House Meerut. 5. J M Hollas, 2002, Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry, RSC, Cambridge.
REFERENCE BOOKS	1. Demtroder. W, Laser Spectroscopy: Basic concepts and Instrumentation, SpringerLink. 2. B. P. Straughan and S. Walker, 1976, Spectroscopy Vol.I., Chapman and Hall, New York. 3. J L McHale, 2008, Molecular Spectroscopy, Pearson Education India, New Delhi. 4. David. L. Andrews, Introduction to Laser Spectroscopy, Springer, 2020 5. Kalsi.P.S, 2016, Spectroscopy of Organic Compounds (7th Edition) New Age International Publishers.
WEB SOURCES	1. Fundamentals of Spectroscopy - Course (nptel.ac.in) 2. http://mpbou.edu.in/slm/mscche1p4.pdf 3. https://onlinecourses.nptel.ac.in/noc20_cy08/preview 4. https://www.coursera.org/lecture/spectroscopy/nmr-spectroscopy-introduction-XCWRu 5. https://serc.carleton.edu/research_education/geochemsheets/techniques/mossbauer.html

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. Apply mathematical theory while working with symmetry operations. To use group theory as a tool to characterize molecules.	**K1, K2**
CO2	Align with the recent advances in semiconductor laser technology combined sensitive spectroscopic detection techniques.	**K3**
CO3	Understand principle behind Mossbauer spectroscopy and apply the concepts of isomer shift and quadrupole splitting to analyse molecules.	**K2, K3**
CO4	Assimilate this XPES quantitative technique and the instrumentation associated with this, as applied in understanding surface of materials.	**K3, K4**
CO5	Employ IR and Raman spectroscopic data along with other data for structural investigation of molecules. Analyze thermodynamic functions and other parameters to evolve molecular models.	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	2	2	3	3	3	3	3	2
CO2	2	2	2	3	3	3	2	3	3	2
CO3	2	2	3	3	3	3	3	2	3	3
CO4	3	2	3	3	2	3	3	3	3	2
CO5	3	2	3	3	3	3	3	3	3	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	2	2	3	3	3	3	3	2
CO2	2	2	2	3	3	3	2	3	3	2
CO3	2	2	3	3	3	3	3	2	3	3
CO4	3	2	3	3	2	3	3	3	3	2
CO5	3	2	3	3	3	3	3	3	3	3

Elective - List 3 – 17. MICROPROCESSOR 8085 AND MICROCONTROLLER 8051	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	MICROPROCESSOR 8085 AND MICROCONTROLLER 8051	ELECTIVE				3	4	75

Pre-Requisites
Knowledge of number systems and binary operations
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 microcontroller 8051

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 MICROCONTROLLERHARDWARE	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 INSTRUCTION SET AND ASSEMBLY LANGUAGE PROGRAMMING	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 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).
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. A. NagoorKani, Microprocessors & Microcontrollers, RBA Publications (2009). 2. A. P. Godse and D. A. Godse, Microprocessors, Technical Publications, Pune (2009). 3. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with 8085, Penram International Publishing (2013). 4. B. Ram, Fundamentals of Microprocessors & Microcontrollers, DhanpatRai publications New Delhi (2016). 5. V. Vijayendran, 2005, Fundamentals of Microprocessor-8085", 3rd Edition S.Visvanathan Pvt, Ltd.
REFERENCE BOOKS	1. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware, Tata Mc Graw Hill Publications (2008) 2. Muhammad Ali Mazidi, Janice GillispieMazidi, Rolin D. Mckinlay, The 8051 Microcontroller and Embedded Systems, Pearson Education (2008). 3. Barry B. Brey, 1995, The Intel Microprocessors 8086/8088, 80186, 80286, 80386 and 80486, 3rd Edition, Prentice- Hall of India, New Delhi. 4. J. Uffrenbeck, "The 8086/8088 Family-Design, Programming and Interfacing, Software, Hardware and Applications", Prentice-Hall of India, New Delhi. 5. W. A. Tribel, Avtar Singh, "The 8086/8088 Microprocessors: Programming, Interfacing, Software, Hardware and Applications", Prentice-Hall of India, New Delhi.

WEB 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 microprocessor.	**K1**
CO2	Get knowledge of architecture and working of 8051 Microcontroller.	**K1**
CO3	Be able to write simple assembly language programs for 8085A microprocessor.	**K2, K3**
CO4	Able to write simple assembly language programs for 8051 Microcontroller.	**K3, K4**
CO5	Understand the different applications of microprocessor and microcontroller.	**K3,K 5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	3	1	1	1	1	1
CO2	2	1	1	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1
CO5	3	3	3	3	3	1	1	1	1	1

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	2	3	3	3	3	1	1	1	1	1
CO2	2	1	1	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1
CO5	3	3	3	3	3	1	1	1	1	1

Elective - List 3 – 18.CHARACTERIZATON OF MATERIALS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	CHARACTERIZATON OF MATERIALS	ELECTIVE				3	4	75

Pre-Requisites
Fundamentals of Heat and Thermodynamics, Basics of Optical systems, Microscopic systems, Electrical measurements and Fundamentals of Spectroscopy.
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 tunnelingmicroscopy (STEM) - Atomic force microscopy (AFM) - Scanning new field optical microscopy.
UNIT IV ELECTRICAL METHODS AND	Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity

OPTICAL CHARACTERISATION	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.
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. R. A. Stradling and P. C. Klipstain. Growth and Characterization of semiconductors. Adam Hilger, Bristol, 1990. 2. J. A. Belk. Electron microscopy and microanalysis of crystalline materials. Applied Science Publishers, London, 1979. 3. Lawrence E. Murr. Electron and Ion microscopy and Microanalysis principles and Applications. Marcel Dekker Inc., New York, 1991 4. D. Kealey and P. J. Haines. Analytical Chemistry. Viva Books Private Limited, New Delhi, 2002. 5. Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press,(2008).
REFERENCE BOOKS	1. Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001). 2. Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging,Wiley-Liss, Inc. USA, (2001). 3. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49 – 51, (2009).Volumes 49 – 51, (2009). 4. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, (1986). 5. Wachtman, J.B., Kalman, Z.H., Characterization of Materials, ButterworthHeinemann, (1993)
WEB SOURCES	1. https://cac.annauniv.edu/uddetails/udpg_2015/77.%20Mat%20Sci(AC).pdf 2. http://www.digimat.in/nptel/courses/video/113106034/L11.html 3. https://nptel.ac.in/courses/104106122 4. https://nptel.ac.in/courses/118104008 5. https://www.sciencedirect.com/journal/materials-characterization

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, K3**
CO2	The concept of image formation in Optical microscope, developments in other specialized microscopes and their applications.	**K2**
CO3	The working principle and operation of SEM, TEM, STM and AFM.	**K2, K3**
CO4	Understood Hall measurement, four –probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence experimental techniques with necessary theory.	**K3, K4**
CO5	The theory and experimental procedure for x- ray diffraction and some important spectroscopic techniques and their applications.	**K4,K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	2	2	2	2	2	3
CO2	3	3	3	2	2	2	2	2	2	2
CO3	3	3	2	2	2	3	2	2	2	2
CO4	2	2	2	3	2	3	2	2	2	2
CO5	2	2	2	2	2	2	3	2	2	2

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	2	2	2	2	2	2	3
CO2	3	3	3	2	2	2	2	2	2	2
CO3	3	3	2	2	2	3	2	2	2	2
CO4	2	2	2	3	2	3	2	2	2	2
CO5	2	2	2	2	2	2	3	2	2	2

Elective - List 3 – 19. MEDICAL PHYSICS	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	MEDICAL PHYSICS	ELECTIVE				3	4	75

Pre-Requisites

Fundamentals of physiological concepts, Basics of instruments principle,

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 therapy and different applications in medical physics.
- To introduce the ideas of Radiography.
- To form a good base for further studies like research.

UNITS	CourseDetails
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)
UNITV: RADIATION PROTECTION	Principles of Radiation Protection – Protective Materials – Radiation Effects – Somatic – Genetic Stochastic and Deterministic Effect – Personal Monitoring Devices – TLD Film Badge – Pocket Dosimeter

UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism
TEXT BOOKS	1. Dr.K.Thayalan ,*Basic Radiological Physics*, Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi, 2003. 2. Curry, Dowdey and Murry, *Christensen's Physics of Diagnostic Radiology: -Lippincot*Williams and Wilkins, 1990. 3. FM Khan, *Physics of Radiation Therapy*, William and Wilkins, 3rd ed, 2003. 4. D. J. Dewhurst, *An Introduction to Biomedical Instrumentation*, 1st ed, Elsevier Science, 2014. 5. R.S. Khandpur, *Hand Book of Biomedical Instrumentations*, 1st ed, TMG, New Delhi, 2005.
REFERENCE BOOKS	1. Muhammad Maqbool, *An Introduction to Medical Physics*, 1st ed, Springer International Publishing, 2017. 2. Daniel Jirák, FrantišekVítek, *Basics of Medical Physics*, 1st ed, Charles University, Karolinum Press, 2018 3. Anders Brahme, *Comprehensive Biomedical Physics*, Volume 1, 1st ed, Elsevier Science, 2014. 4. K. Venkata Ram, *Bio-Medical Electronics and Instrumentation*, 1st ed, Galgotia Publications, New Delhi, 2001. 5. John R. Cameron and James G. Skofronick, 2009, Medical Physics, John Wiley Interscience Publication, Canada, 2nd edition.
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**
CO2	Understand the basics of blood pressure measurements. Learn about sphygmomanometer, EGC, ENG and basic principles of MRI.	**K2**
CO3	Apply knowledge on Radiation Physics	**K3**
CO4	Analyze Radiological imaging and filters	**K4**
CO5	Assess the principles of radiation protection	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) **and** LOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	1	1	2	3	3	1	3
CO2	3	3	3	2	1	2	3	3	1	3
CO3	3	3	3	2	1	2	3	3	1	3
CO4	3	3	3	2	1	2	3	3	1	3
CO5	3	3	3	1	1	2	3	3	1	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	3	3	3	1	1	2	3	3	1	3
CO2	3	3	3	2	1	2	3	3	1	3
CO3	3	3	3	2	1	2	3	3	1	3
CO4	3	3	3	2	1	2	3	3	1	3
CO5	3	3	3	1	1	2	3	3	1	3

Elective - List 3 – 20. SOLID WASTE MANAGEMENT	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	SOLID WASTE MANAGEMENT	ELECTIVE				3	4	75

Pre-Requisites
Basic knowledge of solid waste and its type
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
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Handbook of Solid Waste Management /Second Edition, George Tchobanoglous, McGraw Hill (2002). 2. Prospects and Perspectives of Solid Waste Management, Prof. B BHosett, New Age International (P) Ltd (2006). 3. Solid and Hazardous Waste Management, Second Edition, M.N Rao, BS Publications / BSPBooks (.(2020 4. Integrated Solid Waste Management Engineering Principles and Management, Tchobanoglous, McGraw Hill (2014). 5. Solid Waste Management (SWM), Vasudevan Rajaram, PHI learning private limited, 2016
REFERENCE BOOKS	1. Municipal Solid Waste Management, Christian Ludwig, Samuel Stucki, Stefanie Hellweg, Springer Berlin Heisenberg, 2012 2. Solid Waste Management Bhide A. D Indian National Scientific Documentation Centre, New Delhi Edition 1983 ASIN: B0018MZ0C2 3. Solid Waste Techobanoglous George; Kreith, Frank McGraw Hill Publication, New Delhi 2002, ISBN 9780071356237 4. Environmental Studies Manjunath D. L. Pearson Education Publication, New Delhi, 20061SBN-I3: 978-8131709122 5. Solid Waste Management Sasikumar K. PHI learning, New Delhi, 2009 ISBN 8120338693
WEB 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**
CO2	Equipped to take up related job by gaining industry exposure	**K5**
CO3	Develop entrepreneurial skills	**K3**
CO4	Will be able to analyze and manage the status of the solid wastes in the nearby areas	**K4**
CO5	Adequately sensitized in managing solid wastes in and around his/her locality	**K5**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	3	3	2	2	2	2	2	3
CO2	2	3	3	2	2	2	3	3	3	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	3	2	2	2	2	3	3	3	3	2
CO5	2	3	3	2	2	2	3	3	2	3

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	2	3	3	3	2	2	2	2	2	3
CO2	2	3	3	2	2	2	3	3	3	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	3	2	2	2	2	3	3	3	3	2
CO5	2	3	3	2	2	2	3	3	2	3

Elective - List 3 –21. SEWAGE AND WASTE WATER TREATMENT AND REUSE	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	SEWAGE AND WASTE WATER TREATMENT AND REUSE	ELECTIVE				3	4	75

Pre-Requisites
Basic knowledge of classification of sewage and solid waste and its harmful effects.
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
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Drinking water and disinfection technique, Anirudhha Balachandra. CRC press (2013) 2. Design of Water and Wastewater Treatment Systems (CV-424/434), ShashiBushan,(2015) Jain Bros 3. Integrated Water Resources Management, Sarbhukan M M, CBS PUBLICATION (2013) 4. C.S. Rao, Environmental Pollution Control Engineering, New Age International, 2007 5. S.P. Mahajan, Pollution control in process industries, 27th Ed. Tata McGraw Hill Publishing Company Ltd., 2012.
REFERENCE BOOKS	1. Handbook of Water and Wastewater Treatment Plant Operations, Frank. R Spellman, CRC Press, 2020 2. Wastewater Treatment Technologies, MritunjayChaubey, Wiley, 2021. 3. Metcalf and Eddy, Wastewater Engineering, 4th ed., McGraw Hill Higher Edu., 2002. 4. W. Wesley Eckenfelder, Jr., Industrial Water Pollution Control, 2nd Edn., McGraw Hill Inc., 1989 5. Lancaster, Green Chemistry: An Introductory Text, 2nd edition, RSC publishing, 2010.
WEB 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 4. https://www.meripustak.com&gclid=Cj0KCQjwuuKXBhCRARIsAC-gM0iVpismAJN93CHA1sX6NuNeOKLXfQJ jxHCOVH3QXjJ1iACq30KofoaAmFsEALw_wcB 5. https://www.amazon.in/Design-Wastewater-Treatment-Systems-CV-424/dp/B00IG2PI6K/ref=asc_df_B00IG2PI6K/?tag=googleshopmob-21&linkCode=df0&hvadid=397013004690&hvpos=&hvnetw=g&hvrand=4351305881865063672&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9061971&hvtargid=pla-890646066127&psc=1&ext_vrnc=hi

COURSE OUTCOMES:

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

CO1	Gained knowledge in solid waste management	**K1**
CO2	Equipped to take up related job by gaining industry exposure	**K5**
CO3	Develop entrepreneurial skills	**K3**
CO4	Will be able to analyze and manage the status of the solid wastes in the nearby areas	**K4**
CO5	Adequately sensitized in managing solid wastes in and around his/her locality	**K5**
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;		

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	3	3	2	3	2	3	2
CO2	2	3	2	2	3	3	2	3	2	2
CO3	2	2	2	2	2	3	3	3	3	2
CO4	3	2	3	3	2	3	3	3	3	2
CO5	2	2	2	2	3	3	2	2	2	2

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	3	2	3	3	3	2	3	2	3	2
CO2	2	3	2	2	3	3	2	3	2	2
CO3	2	2	2	2	2	3	3	3	3	2
CO4	3	2	3	3	2	3	3	3	3	2
CO5	2	2	2	2	3	3	2	2	2	2

Elective - List 3 – 22. SOLAR ENERGY UTILIZATION	I/II YEAR – SECOND/THIRD SEMESTER

Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
	SOLAR ENERGY UTILIZATION	ELECTIVE				3	4	75

Pre-Requisites

Basic knowledge of heat energy, way of transfer of heat, solar energy, materials types

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 sectorsof 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
UNIT VI: PROFESSIONAL COMPONENTS	Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism

TEXT BOOKS	1. Solar energy utilization -G.D. Rai –Khanna publishers – Delhi 1987. 2. Maheshwar Sharon, Madhuri Sharon, Carbon "Nano forms and Applications", Mc Graw-Hill, 2010. 3. Soteris A. Kalogirou, „Solar Energy Engineering: Processes and Systems",

	Academic Press, London, 2009 4. Tiwari G.N, "Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002 5. Sukhatme S.P. Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
REFERENCE BOOKS	1. Energy – An Introduction to Physics – R.H.Romer, W.H.Freeman.(1976) 2. Solar energy thermal processes – John A.Drife and William. (1974) 3. John W. Twidell& Anthony D.Weir, 'Renewable Energy Resources,2005 4. John A. Duffie, William A. Beckman, Solar Energy: Thermal Processes, 4th Edition, john Wiley and Sons, 2013 5. Duffie, J.A., Beckman, W.A. , "Solar Energy Thermal Process", John Wiley and Sons,2007.
WEB SOURCES	1. https://pdfs.semanticscholar.org/63a5/a69421b69d2ce9f359bbfc86c63556f9a4fb 2. https://books.google.vg/books?id=l-XHcwZo9XwC&sitesec=buy&source=gbs_vpt_read 3. www.nptel.ac.in/courses/112105051 4. www.freevideolectures.com 5. http://www.e-booksdirectory.com

COURSE OUTCOMES:

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

CO1	Gained knowledge in fundamental aspects of solar energy utilization	**K1**
CO2	Equipped to take up related job by gaining industry exposure	**K3**
CO3	Develop entrepreneurial skills	**K5**
CO4	Skilled to approach the needy society with different types of solar cells	**K4**
CO5	Gained industrialist mindset by utilizing renewable source of energy	**K2, K3**
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)** and program specific outcomes **(PSO)** in the 3-point scale of STRONG (3), MEDIUM (2) andLOW (1)**.**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	3	3	2	2	2	3	2
CO2	2	3	2	2	3	3	2	3	2	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	2	2	2	3	2	3	2	3	3	2
CO5	2	2	3	2	3	3	3	3	3	3

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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	3	2	3	3	3	2	2	2	3	2
CO2	2	3	2	2	3	3	2	3	2	2
CO3	2	3	2	2	2	2	3	3	3	2
CO4	2	2	2	3	2	3	2	3	3	2
CO5	2	2	3	2	3	3	3	3	3	3