M.Sc. PHYSICS

LOCF SYLLABUS 2023

Department of Physics
School of Physical Sciences
St. Joseph's College (Autonomous)
Tiruchirappalli - 620 002, Tamil Nadu, India

Vision

Forming globally competent, committed, compassionate and holistic persons, to be men and women for others, promoting a just society.

Mission

- Fostering learning environment to students of diverse background, developing their inherent skills and competencies through reflection, creation of knowledge and service.
- Nurturing comprehensive learning and best practices through innovative and value-driven pedagogy.
- Contributing significantly to Higher Education through Teaching, Learning, Research and Extension.

Programme Educational Objectives (PEOs)

- Graduates will be able to accomplish professional standards in the global environment.
- Graduates will be able to uphold integrity and human values.
- Graduates will be able to appreciate and promote pluralism and multiculturalism in working environment.

Programme Outcomes (POs)

1. Graduates will be able to apply assimilated knowledge to evolve tangible solution to emerging problems.
2. Graduates will be able to analyze and interpret data to create and design new knowledge.
3. Graduates will be able to engage in innovative and socially relevant research and effectively communicate the findings.
4. Graduates will become ethically committed professional and entrepreneurs upholding human values.
5. Graduates imbibed with ethical values and social concern will be able to understand and appreciate cultural diversity, social harmony and ensure sustainable environment.

Programme Specific Objectives (PSOs)

1. Gain the ability to identify and analyse complex Physics problems using the principles of Physics with suitable mathematical tools.
2. Acquire skills which will put the learners at an advantage in careers as drivers to associate with different subjects.
3. Mould to adopt, absorb and develop innovative ideas
4. Develop skills to communicate effectively with peers , professionals and society at large and demonstrate professional ethics
5. Exhibit effective individual talent, and engage themselves in lifelong learning and dissemination

CONTINUOUS INTERNAL ASSESSMENT
Categorizing Outcome Assessment Levels Using Bloom's Taxonomy

Level	Cognitive Domain	Description
K1	Remember	It is the ability to remember the previously learned concepts or ideas.
K2	Understand	The learner explains concepts or ideas.
K3	Apply	The learner uses existing knowledge in new contexts.
K4	Analyse	The learner is expected to draw relations among ideas and to compare and contrast.
K5	Evaluate	The learner makes judgements based on sound analysis.
K6	Create	The learner creates something unique or original.

Question Paper Blueprint for Mid and End Semester Tests

<table>
<tr><td colspan="3">Duration: 2 Hours</td><td colspan="6">Maximum Marks: 60</td></tr>
<tr><td colspan="2" rowspan="2">Section</td><td colspan="6">K level*</td><td rowspan="2">Marks</td></tr>
<tr><td>K1</td><td>K2</td><td>K3</td><td>K4</td><td>K5</td><td>K6</td></tr>
<tr><td colspan="2">A (no choice)</td><td>7</td><td></td><td></td><td></td><td></td><td></td><td>7 × 1 = 7</td></tr>
<tr><td colspan="2">B (no choice)</td><td></td><td>5</td><td></td><td></td><td></td><td></td><td>5 × 3 = 15</td></tr>
<tr><td colspan="2">C (either… or type)</td><td></td><td></td><td>3</td><td></td><td></td><td></td><td>3 × 6 = 18</td></tr>
<tr><td rowspan="4">D (2 out of 3)</td><td>Courses with K4 as the highest cognitive level</td><td></td><td></td><td></td><td>2</td><td></td><td></td><td rowspan="4">2 × 10 = 20</td></tr>
<tr><td>Courses with K5 as the highest cognitive level wherein one question each on K4 and K5 is compulsory.
(Note:K4 has two questions whereas, K5 has no choice.)</td><td></td><td></td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td rowspan="2">Courses with K6 as the highest cognitive level wherein one question each on K5 and K6 is compulsory.
(Note: Mid Sem: K4 has two questions whereas, K5 has no choice; End sem: K5 has two questions whereas, K6 has no choice)</td><td></td><td></td><td></td><td colspan="2">Mid Sem</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">End Sem</td></tr>
<tr><td colspan="6">Total</td><td>60</td></tr>
</table>

** K4 and K5 levels will be assessed in the Mid semester test whereas K5 and K6 levels will be assessed in the End semester test.*

Question Paper Blueprint for Mid and End Semester Tests *(For quantitative courses only)*

Duration: 2 Hours							**Maximum Marks: 60**
Section	**K level**						**Marks**
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	
A *(no choice)*	5	4					9 × 1 = 9
B *(either… or type)*			2	1			3 × 5 = 15
C *(2 out of 3)*					1	1*	2 × 18 = 36
						Total	**60**

NOTE: *K4 and K5 will be assessed in the Mid semester test whereas K5 and K6 will be assessed in the End semester test.*
** K6 compulsory*

SEMESTER EXAMINATION
Question Paper Blueprint for Semester Examination

Duration: 3 Hours								**Maximum Marks: 100**
Section		**K level**						**Marks**
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	
A *(no choice, two questions from each unit)*		10						10 × 1 = 10
B *(no choice, two questions from each unit)*			10					10 × 3 = 30
C *(either… or type, one question from each unit)*				5				5 × 6 = 30
D *(3 out of 5, one question from each unit)*	*Courses with K4 as the highest cognitive level*				3			3 × 10 = 30
	Courses with K5 as the highest cognitive level wherein two K4 questions and one K5 question are compulsory. (Note: Three questions on K4 and two questions on K5)				2	1		
	Courses with K6 as the highest cognitive level wherein one question each on K4, K5, and K6 is compulsory. (Note: Two questions each on K4 and K5 and one question on K6)				1	1	1	
							Total	**100**

Question Paper Blueprint for Semester Examination *(For quantitative courses only)*

Section	Marks	K level
A	10 × 1 = 10	K1
B	5 × 6 = 30 *(either…or)*	K2 *(Q. No. 11 & 12)* K3 *(Q. No. 13, 14 & 15)*
C	4 × 15 = 60 *(4 out of 5)*	K4 *(Q. No. 16 & 17)* K5 *(Q. No. 18 & 19)* K6 *(Q. No. 20 compulsory)*
Total Marks: 100		

Evaluation Pattern for Part IV One/Two Credit Courses

Title of the Course	CIA	Semester Examination	Total Marks
Internship	100		**100**
UG Skill Enhancement Course (Non Major Elective) Foundation Course **PG** Ability Enhancement Course	20 + 10 + 20 = 50	50 *(External member from the Department)*	**100**
Value Education	50	50 *(CoE)*	**100**

M.Sc. PHYSICS							
PROGRAMME PATTERN							
Course Details					**Scheme of Exams**		
Sem	**Course Code**	**Title of the Course**	**Hours**	**Credits**	**CIA**	**SE**	**Final**
1	23PPH1CC01	**Core Course - 1**: Mathematical Physics	6	6	100	100	100
	23PPH1CC02	**Core Course - 2**: Classical Mechanics and Relativity	6	6	100	100	100
	23PPH1CP01	**Core Practical - 1**: Physics Practical - 1	6	4	100	100	100
	23PPH1ES01	**Elective - 1:** Linear and Digital ICs and Applications	5	3	100	100	100
	23PPH1ES02	**Elective - 2:** Physics of Nano Science and Technology	5	3	100	100	100
	23PPH1AE01	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship	2	1	100	-	100
		Total	**30**	**23**			
2	23PPH2CC03	**Core Course - 3**: Quantum Mechanics	5	5	100	100	100
	23PPH2CC04	**Core Course - 4**: Molecular Spectroscopy	4	4	100	100	100
	23PPH2CP02	**Core Practical - 2**: Physics Practical - 2	8	6	100	100	100
	23PPH2SP01A	**Self-paced Learning:** Medical Physics*	-	2	50	50	50
	23PPH2SP01B	**Self-paced Learning:** Crystal Growth and Thin films*					
	23PPH2SP01C	**Self-paced Learning:** Ultrasonics and its Applications*					
	23PPH2SP01D	**Self-paced Learning:** Forensic Physics*					
	23PPH2ES03A	**Elective - 3:** Mathematical Methods of Computational Physics and Python Programming	5	4	100	100	100
	23PPH2ES03B	**Elective - 3:** Physics of Disaster Management					
	23PSS2SE01	**Skill Enhancement Course:** Soft Skills	4	3	100	-	100
	23PPH2EG01A	**Generic Elective - 1 (WS):** Solar Energy and Utilization	4	3	100	100	100
	23PPH2EG01B	**Generic Elective - 1 (WS):** Renewable Energy Resources					
	-	Extra Credit Courses (MOOC/Certificate Courses) - 1	-	(3)			
		Total	**30**	**27(3)**			
3	23PPH3CC05	**Core Course - 5**: Electromagnetic Theory	5	5	100	100	100
	23PPH3CC06	**Core Course - 6**: Condensed Matter Physics	4	4	100	100	100
	23PPH3CC07	**Core Course - 7**: Fiber Optic Communication	4	4	100	100	100
	23PPH3CP03	**Core Practical - 3**: Physics Practical - 3	8	8	100	100	100
	23SPS3CC01	**Common Core:** Materials Science	5	4	100	100	100
	23PPH3EG02A	**Generic Elective - 2 (BS):** Physics for Competitive Exams	4	3	100	100	100
	23PPH3EG02B	**Generic Elective - 2 (BS):** Nano Science					
	-	Extra Credit Courses (MOOC/Certificate Courses) - 2		(3)			
		Total	**30**	**28(3)**			
4	23PPH4CC08	**Core Course - 8**: Nuclear and Particle Physics	6	6	100	100	100
	23PPH4CC09	**Core Course - 9**: Statistical Mechanics and Thermodynamics	5	5	100	100	100
	23PPH4CP04	**Core Practical - 4**: Physics Practical - 4	8	6	100	100	100
	23PPH4ES03A	**Elective - 4:** Microcontroller based Physics Instrumentation	5	4	100	100	100
	23PPH4ES03B	**Elective - 4:** Physics of Sensors and Transducers					
	23PPH4PW01	Project Work and Viva Voce	6	5	100	100	100
	23PPH4CE01	Comprehensive Examination*	-	2	50	50	50
	-	Extra Credit Courses (MOOC/Certificate Courses) - 3	-	(3)			
		Total	**30**	**28(3)**			
2 - 4	23PCW4OR01	Outreach Programme (SHEPHERD)		4			
1 - 4		**Total**	**120**	**110**			

*- for grade calculation 50 marks are converted into 100 in the mark statements

Semester	Course Code	Title of the Course	Hours/ Weeks	Credits
1	23PPH1CC01	**Core Courses -1:** Mathematical Physics	6	5

Course 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
To simplify the given complex problems on 2nd order ODE in terms simple special function solutions
To interpret the essence of various complex mathematical forms in physics

UNIT I: Linear Vector Spaces **(15 Hours)**

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 **(15 Hours)**

Review of Complex Numbers -de Moivre's theorem-Functions of a Complex Variable-Differentiability -Analytic functions- Harmonic Functions- Complex Integration- Contour Integration, Cauchy – Riemann conditions – Singular points – Cauchy's Integral Theorem and integral Formula -Taylor's Series-Laurent's Expansion- Zeros and poles – Residue theorem and its Application: Potential theory-(1) Electrostatic fields and complex potentials-Parallel plates, coaxial cylinders and an annular region (2) Heat problems-Parallel plates and coaxial cylinders

UNIT III: Matrices **(15 Hours)**

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 & Laplace Transforms **(15 Hours)**

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: Second Order Differential Equations & Special Functions (15 Hours)

Second order differential equation- Sturm-Liouville'stheory-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.

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Graphical representation using software, simulation

Books for Study

1. Zettile, N. (2009). *Quantum mechanics: Concepts and applications* (2nd ed.). John Wiley & Sons.
2. Arfken, G. & Weber, H. J. (2012). *Mathematical methods for physicists – A comprehensive guide* (7th ed.). Academic press.
3. Chattopadhyay, P. K. (2013). *Mathematical physics* (2nd ed.). New Age.
4. Joshi, A. W. (2017). *Matrices and tensors in physics* (4th ed.). New Age International Pvt. Ltd.
5. Gupta, B. D. (2009). *Mathematical physics*. Vikas Publishing House.
6. Dass, H. K & Verma, R. (2014). *Mathematical physics* (7th Revised ed.). S. Chand & Company Pvt. Ltd.

Books for Reference

1. Kreyszig, E. (1983). *Advanced engineering mathematics*. Wiley Eastern.
2. Zill, D. G & Cullen, M. R. (2006). *Advanced engineering mathematics* (3rd ed.). Narosa.
3. Lipschutz, S. (1987). *Linear algebra*. Schaum's Series, McGraw Hill.
4. Butkov, E. (1968). *Mathematical physics*. Addison - Wesley, Reading, Massachusetts.
5. Halmos, P. R. (1965). *Finite dimensional vector spaces* (2nd ed.). Affiliated East West.
6. Wylie, C. R & Barrett, L. C. (1995). *Advanced engineering mathematics* (6th ed.). International Edition, McGraw-Hill.

Web Resources

1. www.khanacademy.org
2. https://youtu.be/LZnRlOA1_2I
3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath
4. https://www.youtube.com/watch?v=_2jymuM7OUU&list=PLhkiT_RYTEU27vS_SlED56gNjVJGO2qaZ
5. https://archive.nptel.ac.in/courses/115/106/115106086/

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, student will be able to	**Cognitive Levels (K - Level)**
CO1	understand use of bra-ket vector notation, the meaning of complete orthonormal set of basis vectors, and transformations and be able to apply them	**K1**
CO2	be able to understand analytic functions, do complex integration, by applying Cauchy Integral Formula. And to compute many real integrals and infinite problems via complex integration	**K2**
CO3	analyze characteristics of matrices and its different types, and the process of diagonalization.	**K3**
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**
CO5	find the solutions for physical problems using linear differential equations and to solve boundary value problems using Green's function. Apply special functions in computation of solutions to real world problems	**K5**
CO6	formulate and propose the best solution for handling complex ODE problems	**K6**

Relationship Matrix											
Semester	**Course code**	**Title of the Course**								**Hours**	**Credits**
1	**23PPH1CC01**	**Core Courses -1:** Mathematical Physics								**6**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	**3**	**3**	**2**	**2**	**1**	**3**	**3**	**3**	**2**	**2**	**2.4**
CO2	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2.5**
CO3	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2.5**
CO4	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2.5**
CO5	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**2**	**2**	**2.7**
CO6	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	**2**	**2**	**2.6**
Mean overall Score											**2.53 (High)**

Semester	Course Code	Title of the Course	Hours/ Weeks	Credit
1	23PPH1CC02	**Core Courses - 2:** Classical Mechanics and Relativity	6	5

Course Objectives
To make the students to understand fundamentals of classical mechanics
To extend the Lagrangian formulation of mechanics and help the students to apply it to solve equation of motion
To equip the students with Hamiltonian formulation of mechanics and help them to 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

UNIT I: Principles of Classical Mechanics **(18 Hours)**

Mechanics of a single particle – mechanics of a system of particles – conservation laws for a system of particles – constraints – holonomic & non-holonomic constraints – generalized coordinates – configuration space – transformation equations – principle of virtual work.

UNIT II: Lagrangian Formulation **(18 Hours)**

D'Alembert's principle – Lagrangian equations of motion for conservative systems – applications: (i) simple pendulum (ii) Atwood's machine (iii) projectile motion- iv) compound pendulum - linear harmonic oscillator Lagrange's equations in presence of non-conservative forces - generalized potential - Lagrangian of a charged particle in the presence of electromagnetic field - Hamilton's principle - Lagrange's equation of motion from Hamilton's principle - conservation theorems and symmetry properties.

UNIT III: Hamiltonian Formulation **(18 Hours)**

Phase space – cyclic coordinates – conjugate momentum – Hamiltonian function – Hamilton's canonical equations of motion – applications: (i) simple pendulum (ii) one dimensional simple harmonic oscillator (iii) compound pendulum - linear harmonic oscillator iv) motion of particle in a central force field. - Δ-variation - principle of least action- statement and its proof - other forms of the action principle (Jacobi's form).

UNIT IV: Small Oscillations **(18 Hours)**

Formulation of the problem – the Eigen value equation and principle axis transformation – frequency of free vibration and normal coordinates transformation – frequencies of normal modes – linear triatomic molecule – forced vibration and effect of dissipative forces.

UNIT V: Relativity **(18 Hours)**

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 for vector notation and their transformations

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Graphical representation using software, simulation

Books for Study

1. Goldstein, H. & Poole, C. P. (2002). *Classical mechanics* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd.
2. Upadhyaya, J.C. (2022). *Classical mechanics* (3rd ed.). Himalaya Publishing Company.
3. Resnick, R. (1968). *Introduction to special theory of relativity*. Wiley Eastern.
4. Takwala, R. G. & Puranik, P. S. (1980). *Introduction to classical mechanics*.Tata McGraw-Hill.
5. Rana, N. C. & Joag, P. S. (2001). *Classical mechanics*. Tata McGraw-Hill.

Books for Reference

1. Symon, K. R. (1971). *Mechanics*. Addison Wesley..
2. Biswas, S. N. (1999). *Classical mechanics*. Books & Allied, Kolkata.
3. Gupta, B. D. & Prakash, S. (2020). *Classical mechanics*. KNRN Publications.
4. Kibble, T. W. B. (2004). *Classical mechanics*. Imperial College Press.
5. Greenwood, T. (1997). *Classical dynamics*. PHI.

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		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire knowledge about conservation laws, constraints and relativistic mechanics.	**K1**
CO2	understand relativistic mechanics, D' Alemberts concept and Lagrangian.	**K2**
CO3	analyse the cyclic coordinates and apply them for rigid body dynamics.	**K3**
CO4	apply and formulate the equation to solve problems in mechanics and relativistic mechanics.	**K4**
CO5	evaluate the concepts of inertial, non-inertial frames of references and rotating coordinate system in relativistic mechanics.	**K5**
CO6	distinguish the transformation equations in any frame.	**K6**

Relationship Matrix											
Semester	**Course code**	**Title of the Course**								**Hours**	**Credits**
1	**23PPH1CC02**	**Core Courses - 2:** Classical Mechanics and Relativity								**6**	**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	**3**	**2**	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**1**	**2.3**
CO2	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2.3**
CO3	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2.2**
CO4	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2.1**
CO5	**2**	**3**	**3**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2.3**
CO6	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**2.2**
Mean overall Score											**2.23 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
1	23PPH1CP01	**Core Practical -1:** Physics Practical – 1	6	4

ANY 12 EXPERIMENTS

1. Determination of Young's modulus and Poisson's ratio by Hyperbolic fringes – Cornu's Method
2. Measurement of Band gap energy- Thermistor
3. Determination of Specific charge of an electron – Thomson's method
4. Determination of Wavelength, Separation of wavelengths - Michelson Interferometer
5. GM counter – Characteristics and inverse square law
6. Measurement of Conductivity - Four probe method
7. Molecular spectra – AlO band.
8. Measurement of wavelength of Diode Laser / He – Ne Laser using Diffraction grating
9. Measurements of Standing wave and standing wave co-efficient, Law of Inverse square, Receiver end transmitter behavior, Radiation Pattern - Microwave test bench
10. UV-Visible spectroscopy – Verification of Beer-Lambert's law and identification of wavelength maxima – Extinction coefficient
11. Construction of relaxation oscillator using UJT
12. FET CS amplifier- Frequency response, input impedance, output impedance
13. V- I Characteristics of different colours of LED
14. Study of attenuation characteristics of Wien's bridge network and design of Wien's bridge oscillator using Op-Amp
15. Study of attenuation characteristics of Phase shift network and design of Phase shift oscillator using Op-Amp
16. Construction of Schmidt trigger circuit using IC 741 for a given hysteresis-application as squarer
17. Study of R-S, clocked R-S and D-Flip flop using NAND gates
18. Study of J-K, D and T flip flops using IC 7476/7473
19. Arithmetic operations using IC 7483- 4-bit binary addition and subtraction.
20. Study of Arithmetic logic unit using IC 74181

Semester	Course Code	Title of the Course	Hours/ Week	Credits
1	23PPH1ES01	**Elective - 1:** Linear and Digital ICs and Applications	5	3

Course 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
To Expose the digital IC‘s

UNIT I: Integrated Circuits and Operational Amplifier (15 Hours)

Introduction, Classification of IC ‘s, basic information of Op-Amp 741 and its features, the ideal Operational amplifier, Op-Amp internal circuit and Op-Amp. Characteristics.

UNIT II: Applications of Op-Amp (15 Hours)

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 (15 Hours)

ACTIVE FILTERS: Introduction, Butterworth filters – 1st order, 2nd order low pass and high 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 a stable 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 (15 Hours)

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 (15 Hours)

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).

Teaching Methodology	Videos, PPT, Handouts, circuit analysis, mini projects

Books for Study

1. Choudhury, D. R. & Jain, S. B. (2012). *Linear integrated circuit* (4th ed.). New Age International Pvt. Ltd.
2. Gayakwad, R. A. (2012). *OP-AMP and linear integrated circuits* (4th ed.). Prentice Hall / Pearson Education.
3. Theraja, B. L. & Theraja, A. K. (2004). *A textbook of electrical technology*, S. Chand & Company.
4. Mehta, V. K. & Mehta, R. (2008). *Principles of electronics* (12th Edition). S. Chand & Company.
5. Vijayendran, V. (2008). *Introduction to integrated electronics (Digital & Analog)*, S. Viswanathan Printers & Publishers Private Ltd, Reprint.

Books for Reference

1. Franco, S. (1997). *Design with operational amplifiers and analog integrated circuits*. Tata McGraw-Hill.
2. Gray & Meyer. (1995). *Analysis and design of analog integrated circuits*. Wiley International.
3. Malvino & Leach. (2005). *Digital principles and applications* (5th ed.). Tata McGraw-Hill.
4. Floyd & Jain. (2009). *Digital fundamentals* (8th ed.). Pearson Education.
5. Millman & Halkias. (2000). *Integrated electronics*. Tata McGraw Hill, 17th Reprint.

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		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	spell out the basic concepts for the circuit configuration and for the design of linear integrated circuits	**K1**
CO2	illustrate various techniques to develop A/D and D/A converters.	**K2**
CO3	explain the design of linear and non-linear applications circuits using Op-Amp.	**K3**
CO4	analyze the CMOS logic, combinational and sequential circuits	**K4**
CO5	evaluate solutions to the problems and compare the active filters circuits	**K5**
CO6	design and create analog and digital circuits for various applications	**K6**

Relationship Matrix											
Semester	**Course code**	**Title of the Course**								**Hours**	**Credits**
1	**23PPH1ES01**	**Elective - 1:** Linear and Digital ICs and Applications								**5**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**2**	**3**	**2.7**
CO2	**3**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**	**2**	**2.4**
CO3	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**2.5**
CO4	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**2.4**
CO5	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**2.1**
CO6	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**2.5**
Mean overall Score											**2.43 (High)**

Semester	Course Code	Title of the Course	Hours/ Week	Credits
1	23PPH1ES02	**Elective - 2:** Physics of Nano Science and Technology	5	3

Course Objectives
Physics of Nanoscience and Technology is concerned with the study, creation, manipulation and applications at nanometer scale
To provide the basic knowledge about nanoscience and technology
To learn the structures and properties of nanomaterials
To acquire the knowledge about synthesis methods and characterization techniques and its applications
To make the students aware of the application of nanomaterials and nanotechnology in different field

UNIT I: Fundamentals of Nanoscience and Technology (15 Hours)

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 (15 Hours)

Physical properties of Nanomaterials: Melting points, specific heat capacity, and lattice constant - Mechanical behavior: Elastic properties – strength - ductility - superplastic behavior - Optical properties: - Surface Plasmon Resonance – Quantum size effects - Electrical properties - Conductivity, Ferroelectrics and dielectrics - Magnetic properties – super para magnetism – Diluted magnetic semiconductor (DMS).

UNIT III: Synthesis and Fabrication (15 Hours)

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 (15 Hours)

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 (15 Hours)

Sensors: Nano sensors 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.

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Graphical representation using software, simulation

Books for Study

1. Pradeep, T. (2012). *A textbook of nanoscience and nanotechnology*. Tata McGraw-Hill Publishing Company.
2. Shah, M. A. & Ahmad, T. (2010). *Principles of nanoscience and nanotechnology.* Narosa Publishing House Pvt Ltd.
3. Chattopadhyay, K. K. & Banerjee, A. N. (2012). *Introduction to nanoscience and nanotechnology*, PHI Learning Pvt. Ltd.
4. Nalwa, H. S. (2002). *Nanostructured materials and nanotechnology*, Academic Press.
5. Kothari, D. P., Velmurugan, V. & Singh, R. R. (2018). *Nanotechnology and nanoelectronics*. Narosa Publishing House Pvt. Ltd.

Books for Reference

1. Rao, M. S. R. & Singh, S. (2017). *Nanoscience and nanotechnology: Fundamentals to frontiers.* Wiley Publishing.
2. Gao, H. (2004). *Nanostructures and nanomaterials*, Imperial College Press.
3. Booker, R. & Boysen, E. (2005). *Nanotechnology*. Wiley Publishing Inc.
4. Fendler, J. H. (2007). *Nano particles and nanostructured films: Preparation, Characterization and Applications*. John Wiley and Sons.
5. Murty, B. S. et al. (2012). *Textbook of Nanoscience and Nanotechnology*. Universities Press.
6. Diwan, P. & Bharadwaj, A. (2005). *The Nanoscope (Encyclopedia of nanoscience and nanotechnology)*. Vol. IV – Nanoelectronics. Pentagon Press.

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		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	acquire the basic of nanoscience and explore the different types of nanomaterials and should comprehend the surface effects of the nanomaterials.	**K1**
CO2	understand various physical, mechanical, optical, electrical and magnetic properties nanomaterials.	**K2**
CO3	utilize the process and mechanism of synthesis and fabrication of nanomaterials.	**K3**
CO4	analyze the various characterization of Nano-products through diffraction, spectroscopic, microscopic and other techniques.	**K4**
CO5	evaluate the synthesis and fabrication methods suitable for the application of nanomaterials.	**K5**
CO6	develop the nanomaterials integrated devices in the field of sensors, robotics, purification of air and water and in the energy devices.	**K6**

Relationship Matrix											
Semester	**Course code**	**Title of the Course**								**Hours**	**Credits**
1	**23PPH1ES02**	**Elective - 2:** Physics of Nano Science and Technology								**5**	**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**3**	**2**	**1**	**2.4**
CO2	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**3**	**2**	**1**	**2.2**
CO3	**3**	**3**	**2**	**2**	**1**	**3**	**3**	**2**	**2**	**1**	**2.4**
CO4	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**3**	**2**	**1**	**2.2**
CO5	**3**	**3**	**2**	**2**	**1**	**3**	**3**	**2**	**2**	**1**	**2.4**
CO6	**3**	**3**	**3**	**2**	**1**	**3**	**3**	**3**	**2**	**1**	**2.2**
Mean overall Score											**2.3 (High)**

Semester	Course code	Title of the Course	Hours	Credit
1	23PPH1AE01	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship	2	1

Course Objectives
To know the fundamentals of research methodologies
To train the students to write research articles and scientific reports
To introduce the innovation and incubator concepts
To create awareness about intellectual properties and their protection
To know the process involved in copy rights and patent registration

UNIT I: Research Methodology **(6 Hours)**

Meaning and objectives of research- motivation in research- Types of research- Research Approaches-Significance of Research-Research Methods versus Methodology-Research and Scientific Method- research process-Criteria of Good Research

UNIT II: Research Writing **(6 Hours)**

Significance of report writing -Different steps in writing report- Layout of the research report - Types of reports - Oral presentation -mechanics of writing a research report-precautions for writing research reports - Search engines & research papers – free digital library– Plagiarism

UNIT III: Innovation & Incubators **(6 Hours)**

Innovation -Managerial Innovation -Open Innovation- **Incubators:** Definitions- Start-ups – Types and characteristics of various incubators of start-ups - The entrepreneurial policy of large groups

UNIT IV: Intellectual Properties **(6 Hours)**

Intellectual Property: Definition, Types: trademarks, Copyright, Patents, and Trade Secrets- Importance- International Organizations, Agencies, and Treaties - **Types of Marks:** Trademarks, Service Marks, Certification Marks, and Collective Marks - Trade Names and Business Names

UNIT V: Copy Rights & Patents **(6 Hours)**

Copy Rights: Introduction – Originality of Material, Fixation of Material, Works of Authorship - Exclusions from Copyright Protection - **Patents:** Patentability, searching patents- The Indian patent act 1970.

Teaching Methodology	Chalk and talk, PPT, Mathematical models, Graphical representation using software, simulation

Books for Study

1. Kothari, C.R. (2004). *Research methodology*, (2nd ed.). New Age International (P) Ltd.

2. Latouche, P. (2019). *Open innovation: Corporate incubator*. ISTE Ltd.

3. Bouchoux, D. E. (2013). *Intellectual Property* (4th ed.). Cengage Learning.

Book for Reference

1. Bansal, K. & Bansal, P. (2020). *Fundamentals of Intellectual Property for Engineers*. BS Publication.

Web Resources

1. https://ipindia.gov.in/
2. https://mic.gov.in/assets/doc/startup_policy_2019.pdf

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K - Level)**
CO1	classify various types of reports, intellectual properties, agencies, treaties and public policies.	**K4**
CO2	evaluate situation in research, intellectual property and innovation-incubator system in India.	**K5**
CO3	create a pre-incubation process that involves a technology-based business idea and executing the business model through startup.	**K6**

3.

Relationship Matrix											
Semester	**Course code**	**Title of the Course**								**Hours**	**Credits**
1	**23PPH1AE01**	**Ability Enhancement Course:** Framework for Physics Innovation and Entrepreneurship								**2**	**1**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	**3**	**3**	**3**	**2**	**2**	**1**	**3**	**3**	**3**	**3**	**2.6**
CO2	**3**	**3**	**3**	**2**	**2**	**1**	**3**	**3**	**3**	**3**	**2.6**
CO3	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**3**	**2.6**
Mean overall Score											**2.6 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2CC03	**Core Courses - 3:** Quantum Mechanics	5	5

Course Objectives
To retrieve the fundamentals and the connection between classical and quantum mechanics.
To infer different square well potentials and eigen value problems.
To execute the problems in cartesian, spherical polar coordinates and angular momentum.
To explain Schrodinger equation, potential well, approximation methods and perturbation theory.
To assess the properties of 1D motion, 3D problems in spherical polar coordinates and transition rates.
To solve quantum mechanical problems.

UNIT I: Basic Postulates and Quantum Systems (15 Hours)

Introduction - The basic postulates of Quantum Mechanics (QM) - The state of a system - observables and operators - Measurement in QM: how measurements disturb systems - expectation values - CSCO - measurement and the uncertainty relation; Time Evolution of the system's state: time evolution operator - stationary states - Schrodinger equation and wave packets - conservation of probability - time evaluation of expectation values; Connecting Quantum Mechanics to Classical Mechanics. Properties of 1D motions: Bound, unbound states, mixed spectrum - The free particle continuous states - the potential step.

UNIT II: One and Three – Dimensional Problems (15 Hours)

The potential barrier & well: $E > Vo$, $E < Vo$: Tunelling, tunnelling effect - the infinite square well potential: Asymmetric square - symmetric; the finite square well potential: Scattering solutions ($E > Vo$), Bound state solution ($0 < E < Vo$) - Harmonic oscillator: Energy Eigenvalues, Energy Eigen states - 3D problems in Cartesian coordinates: General treatment, free particle - 3D problems in spherical coordinates: central potential, the free particle, the hydrogen atom.

UNIT III: Angular Momentum (15 Hours)

General formalism - Geometrical representation - Spin angular momentum: Experimental evidence of spin, general theory of spin, spin ½ and Pauli Matrices - Eigen functions of orbital angular momentum: Eigen functions and Eigenvalues of Lz, Eigen functions of L^2 - Addition of Angular Momenta: General formalism of CG Coefficient.

UNIT IV: Approximation Methods for Stationary States (15 Hours)

Time independent Perturbation Theory: Non-degenerate, Degenerate - Variational method - JWKB method: General formalism, bound states for potential wells with NO and ONE rigid walls, tunnelling through potential barrier.

UNIT V: Time Dependent Perturbation Theory (15 Hours)

The different pictures: The Schrodinger, The Heisenberg, The Interaction - Transition probability: Constant and Harmonic perturbation - adiabatic and sudden approximation - Transition rates: Absorption and Emission radiation, within the dipole approximation.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Zettile, N (2009), *Quantum Mechanics: Concepts and Applications* (2nd Ed.). John Wiley & Sons.

Unit	Book	Chapters	Sections
I	1	3 & 4	3.1, 3.2, 3.3**,** 3.3.1, 3.3.2,3.4, 3.5, 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.6, 3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.8, 3.8.1, 3.8.2, 3.8.3, 4.2.1, 4.2.2, 4.2.3, 4.3, 4.4,
II	1	4 & 6	4.5, 4.5.1, 4.5.2, 4.5.3, 4.6.1, 4.6.2, 4.7, 4.7.1, 4.7.2, 4.8, 4.8.1, 4.8.2, 4.8.3, 6.2.1, 6.2.2, 6.3.1, 6.3.2, 6.3.5
III	1	5 & 7	5.1, 5.2, 5.3, 5.5, 5.6.1, 5.6.2, 5.6.3, 5.7, 5.7.1, 5. 7.3, 7.3.1, 7.3.2,
IV	1	9	9.1, 9.2, 9.2.1, 9.3, 9.4, 9.4.1, 9.4.2, 9.4.3, 9.4.4, 9.4.5
V	1	10	10.1, 10.2, 10.2.1, 10.2.2, 10.2.3, 10.3, 10.3.1, 10.3.2, 10.3.3, 10.4, 10.4.1, 10.4.2, 10.5.3, 10.5.4

Books for Reference

1. Shankar, R. (2014), *Principles of Quantum Mechanics* (2nd Ed.). Springer.
2. Feynman, R. (2012), *Feynman lectures on Physics - Vol 3* (new millennium edition), Pearson.
3. Merzbacher, E. (2011), Quantum *Mechanics*, (3rd Ed.). Wiley.
4. Bransden, B., & Joachain, C. (2004), *Quantum Mechanics* (2nd Ed.). Pearson.
5. Rogalski, M. S., & Palmer, S. B. (1999), *Quantum Physics*, (1st Ed.). CRC Press.
6. Leonard, I.S. (1968), *Quantum Mechanics*, (International student Edition), McGraw Hill.

Websites and eLearning Sources*

1. Visual quantum mechanics: https://vqm.uni-graz.at/
2. https://ocw.mit.edu/courses/physics/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?cat
4. https://nptel.ac.in/courses/115/106/115106066/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	describe the principles and methods of wave mechanics and matrix mechanics based on Dirac notation.	**K1**
CO2	explain quantum mechanical methods to study angular momentum and various perturbed systems.	**K2**
CO3	apply the quantum theory to 1D potentials, 3D potentials, rotation & addition of angular momenta, stationary states and time-dependent systems.	**K3**
CO4	analyse various properties using the quantum theory and compare it with the results of classical physics.	**K4**
CO5	evaluate the methods and properties of various quantum mechanical systems.	**K5**
CO6	summarize the methods and properties of various quantum mechanical systems.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2CC03**			**Core Course - 3:** Quantum Mechanics					**5**		**5**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	2	1	3	3	2	2	2	**2.3**
CO2	3	3	2	2	1	3	3	2	2	2	**2.3**
CO3	3	3	2	2	1	3	3	2	2	2	**2.3**
CO4	3	3	2	2	1	3	3	2	2	2	**2.3**
CO5	3	3	2	2	2	3	3	2	2	2	**2.4**
CO6	3	3	2	2	2	3	3	2	2	2	**2.4**
Mean Overall Score											**2.32 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2CC04	**Core Course - 4:** Molecular Spectroscopy	4	4

Course Objectives
To know the basic concepts and methods in molecular spectroscopy.
To understand the theory behind various spectroscopic techniques.
To choose spectroscopic techniques based on the properties to be investigated.
To analyze and evaluate various spectra of molecules using different methods.
To predict the properties of molecules from the spectra by various techniques and solve chemical structures of molecules.

UNIT I: Microwave Spectroscopy **(12 Hours)**

Characterization of Electromagnetic Radiation - Quantization of energy - Regions of the Electromagnetic spectrum, width and Intensity of spectral lines - Rotation of Molecules, Rotational Spectra - A Diatomic Rigid Rotator - Intensity of Spectral lines - Effect of isotopic substitution.

UNIT II: Infra-Red Spectroscopy **(12 Hours)**

Vibrating diatomic molecule - Simple Harmonic Oscillator - anharmonic oscillator, diatomic vibrating rotator, vibrations of polyatomic molecules - fundamental vibrations and their symmetry - overtones and combination frequencies.

UNIT III: Raman Spectroscopy **(12 Hours)**

Introduction - Quantum theory of Raman effect - Classical theory of Raman effect - Pure rotational Raman spectra - Linear molecules, symmetry top molecules, asymmetric top molecules - vibrational Raman spectra - Raman activity of vibrations - rule of Mutual Exclusion.

UNIT IV: Electronic Spectroscopy of Molecules **(12 Hours)**

Born Oppenheimer approximation - vibrational coarse structure, Frank-Condon Principle - Intensity of vibrational - electronic spectra - dissociation energy and dissociation products - Molecular photo-electron spectroscopy - X-ray photoelectron spectroscopy.

UNIT V: Spin Resonance Spectroscopy **(12 Hours)**

Spin and an applied field - nature of spinning particles - interaction between spin and a magnetic field - population of energy levels - the Larmor Precession - Fourier Transform Nuclear Magnetic Resonance spectroscopy - Electron-spin Resonance Spectroscopy - g factor - hyperfine structure due to electron - nucleus coupling - double resonance - techniques in ESR spectroscopy.

Teaching Methodology	Lectures, Demonstrations, Presentations and Videos

Book for Study

1. Banwell, C. N., & Mccash, E. M. (2014). *Fundamentals of molecular spectroscopy,* (4th Ed.). Tata McGraw-Hill Ltd.

Unit	Chapters	Sections
I	1,2	1.1, 1.2, 1.3, 1.7, 2.1, 2.2, 2.3-2.3.1, 2.3.2, 2.3.3
II	3	3.1-3.1.1, 3.1.3, 3.1.3, 3.2, 3.5-3.5.1, 3.5.2
III	4	4.1- 4.1.1, 4.1.2, 4.2-4.2.1, 4.2.2, 4.2.3, 4.2.3, 4.3-4.3.1, 4.3.2
IV	6	6.1-6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.5-6.5.1, 6.5.2
V	7	7.1- 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1, 7.5-7.5.1, 7.5.2, 7.5.3, 7.5.4, 7.5.6

Books for Reference

1. Aruldhas, G. (2014). *Molecular Structure and Spectroscopy,* (2nd Ed.). PHI Learning Private Ltd.
2. Svanberg, S. (2004). *Atomic and Molecular Spectroscopy,* (4th Ed.). Springer.
3. McHale, J. L. (2017). *Molecular Spectroscopy,* (2nd Ed.). CRC Press.
4. Straughan, B. P., & Walker, S. (1976). *Spectroscopy Volume 1-3,* Chapman & Hall Publishers.
5. Chatwal, G. R., & Anand, S. K. (2009). *Spectroscopy.* Himalaya Publishing House.

Websites and eLearning Sources*

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+4mIqRALksfwQH9v8YSMrw==
2. https://swayam.gov.in/explorer?category=Physics
3. https://edu.rsc.org/resources/analysis
4. https://www.nist.gov/pml/molecular-microwave-spectral-databases
5. https://srdata.nist.gov/xps/Default.aspx

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	acquire knowledge of various spectroscopic methods such as MW, IR, Raman, Electronic and spin resonance spectra.	**K1**
CO2	explain the theory and understanding the techniques of molecular spectra.	**K2**
CO3	apply the principle of molecular and resonance spectra for solving various types of molecules.	**K3**
CO4	analyze and distinguish molecular rotational, vibrational, electronic spectra and chemical shift in different resonance spectra.	**K4**
CO5	evaluate and justify the molecular spectra based on rotation-vibration as well fine structure studies in electronic spectra.	**K5**
CO6	predict the properties of molecules from the spectra by various techniques and solve chemical structures of molecules.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2CC04**			**Core Course - 4:** Molecular Spectroscopy					**4**		**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	3	2	3	2	3	2	1	**2.3**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	2	2	3	3	2	2	3	2	1	**2.3**
CO4	3	2	2	3	3	2	3	3	2	1	**2.4**
CO5	3	3	2	3	3	2	2	3	2	1	**2.3**
CO6	3	2	3	3	3	2	2	3	2	1	**2.3**
										Mean Overall Score	**2.31 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2CP02	**Core Practical - 2:** Physics Practical - 2	8	6

Any 15 Experiments

1. Michelson Interferometer – wavelength, separation and thickness of thin sheet
2. Biprism – Optic bench - wavelength, separation and thickness of thin sheet
3. Energy Gap study of a semiconductor
4. Elastic Constants – Hyperbolic fringes
5. Laser: Magneto-striction, Faraday effect and Verdert constant of a given material
6. e-Millikan's oil drop method
7. Ultrasonic diffraction – velocity and compressibility in liquids
8. Determination of e/k using Ge and Si transistors
9. Permittivity of a liquid using RFO
10. Determination of phase transition temperatures of a binary liquid mixture at different concentrations
11. Polarizability of liquids
12. Fermi-Curie plot of the X-ray / Gamma ray spectrum and determination of end-point energy
13. Determination of transition temperature in liquid crystalline materials
14. Characteristics of laser and tunnel diode
15. Characteristics of LVDT
16. Characteristics of load cell
17. SCR – Characteristics and Applications
18. Study of regulated power supply – monolithic IC
19. Transmission Line Characteristics
20. Shift Registers using Flip-Flop & ICs
21. Design of ROM and RAM using diode / OR gate and flip flop
22. Design of Encoder and Decoder
23. Op-amp: Low, High and band pass Filters
24. Computational experiment: Curve fitting – Least square fitting
25. Computational experiment: Solving Schrodinger equation for hydrogen / LHO
26. Computational experiment: Op-Amp parameter study – Circuit simulation using Proteus
27. Computational experiment: Linear Harmonic Oscillator problem using Hamilton's equation
28. Determination of the wavelength of an unknown light source and the distance between the grooves of a compact disk.
29. Determination of band gap of a semiconductor sample using UV-VIS spectroscopy
30. Study of magnetic hysteresis in ferromagnetic materials

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2SP01A	**Self-paced Learning:** Medical Physics	-	2

Course Objectives
To recall the concepts of mechanics, thermodynamics, optics, acoustics and electromagnetism.
To understand the anatomy and physiological functions of human body.
To use the acoustical and imaging techniques and to measure pressures, temperature and blood velocity of the body.
To analyse medical reports.
To evaluate the physiological functions of the human body.
To combine the principles of physics and biology and to develop sustainable life.

UNIT I: Biomechanics

Motion in the Human machine - the standard human - material components of the body - bone - ligaments and tendons - cartilage - bone shortening - energy storage in tendons and long bones, muscles: skeletal muscles - the structure of muscles - passive muscles - activating muscles - the effect of exercise - levers - the elbow - the hip - the back - elasticity of bone, tissue, visco elasticity. pressures in the body: pressure in the cardiovascular system - hydrostatic pressure - bladder pressure - respiratory pressures - foot pressures - eye and ear pressures - biomechanical measurement - X-ray imaging technique.

UNIT II: Cardiovascular and Respiratory System

Cardiovascular System: circulatory system and cardiac cycle - physics of the circulation system: properties of blood - blood pressure and flow in vessels - capillaries and osmotic pressure - blood flow rates and speeds - consequences of clogged arteries - work done by the heart and the metabolic needs of the heart - blood velocity measurement - The Doppler effect - ECG, lungs and breathing: lungs - alveoli - breathing - volume of the lungs - breathing under usual and unusual conditions - work needed to breathe.

UNIT III: Heat and Energy Transfer in Human Body

Metabolism: energy, heat, work, and power of the body - conservation of energy and heat flow - energy content of body fuel - energy storage molecules - loss of body heat - body temperature - energy requirement - energy from food - regulation of body temperature - resistance to cold - diffusion through membranes thin-film flowmeters - thermistor flowmeters - thermal dilution - thermal conductivity methods - thermography.

UNIT IV: Bio-Acoustics and Bio-Optics

Acoustic Buzzer - voice filtering theory - parameters of voice - energetic speaking. auditory sensitivity - connections to hearing perceptions. structure of the eye - imaging and detection by the eye - transmission of light in the eye - the eye as a compound lens - accommodation ultrasonic imaging - theory and instrumentation.

UNIT V: Electrophysiology and Nuclear Medicine

Biological potentials - the nervous system - neural communication, the interface between ionic conductors: Nernst equation - membranes and nerve conduction - muscle action potentials - neural stimulation - tissue as a leaky dielectric - low-frequency effects: (0.1 Hz-100 kHz) - higher frequencies (>100 kHz) - physiological effects of electricity - electricity in bone. nuclear medicine - MRI - general principles - slice selection - phase encoding - frequency encoding - K space formalism, instrumentation: magnet design - magnetic field gradient coils - RF coils imaging sequences - imaging characteristics - contrast agents functional MRI, applications: brain, liver, skeletal and cardiac systems.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Herman, I.P. (2007). *Physics of Human Body,* (1st Ed.). Springer.
2. Davidovits, P. (2008). *Physics in Biology and Medicine*, (3rd Ed.). Elsevier.
3. Brown, B. H. (1999). *Medical Physics and Biomedical Engineering,* (1st Ed.). IOP Publishing.
4. Webb, A. G. (2003). *An Introduction to Biomedical Imaging,* (1st Ed.). Wiley.

Unit	Book	Chapters	Sections
	1	1, 4	1.2, 1.3, 4.1, 4.2.3, 4.2.4, 4.6, 4.7
I	2	1, 3, 8, 18	1.1, 3.2, 3.8, 8.5, 8.11, 18.4
	3	1, 2	1.2, 2.2
	4	1	1.3-1.9
II	1	8	8.1, 8.2.1-8.2.6, 9.6
	3	19	19.7.1
	1	6	6.1-6.6
III	2	9, 11	9.6, 11.1, 11.2, 11.9,
	3	19	19.4
	1	10, 11	10.2, 10.3, 11.3.1-11.3.3
IV	2	15	15.7
	4	3	3.1, 3.4-3.8
	3	8, 16	8.2, 8.5, 8.6, 8.8.1, 16.1.1-16.1.5, 16.5
V	2	13	13.3
	4	4	4.1, 4.7, 4.10

Books for Reference

1. Maqbool, M. (2017). *An Introduction to Medical Physics.* Springer.
2. Jelinkova, H. (2013). *Lasers for Medical applications, diagnostics, therapy and surgery,* (1st Ed.)., Elsevier.
3. Khandpur, R. S. (2014). *Handbook of Biomedical Instrumentation,* (3rd Ed.). McGraw Hill.

Websites and eLearning Sources*

1. https://medicalphysics.duke.edu/about/what-is-medical-physics/
2. https://medicalphysics.duke.edu/about/what-is-medical-physics/
3. https://www.news-medical.net/health/The-Role-of-Physics-in-Medicine.aspx

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	acquire knowledge about the mechanics of human body, the energy transfer in metabolism, the fluid dynamics of blood flow through vessels, the mechanisms for speaking, hearing, vision and neural communications.	**K1**
CO2	understand the anatomy and physiological functions of human body, medical imaging data in clinical use and	**K2**
CO3	apply physics principles, instrumental design, data acquisition strategies and imaging modalities in biomedical imaging.	**K3**
CO4	analyze physics concepts involved in human body and physiology.	**K4**
CO5	evaluate the physiological functions of the human body	**K5**
CO6	create the awareness of lab facilities for better medical treatment	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2SP01A**			**Self-paced Learning:** Medical Physics					**-**		**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	3	2	2	2	2	2	2	3	**2.3**
CO2	3	2	2	2	3	2	2	3	2	2	**2.3**
CO3	2	2	2	2	2	3	2	2	2	2	**2.1**
CO4	3	3	3	2	3	2	2	2	2	3	**2.5**
CO5	2	2	3	2	3	3	2	2	2	2	**2.3**
CO6	3	2	2	2	3	2	2	3	2	2	**2.3**
Mean Overall Score											**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2SP01B	**Self-paced Learning:** Physics of Crystal Growth and Thin Films	-	2

Course Objectives
To recall the fundamental phases of matter and energy.
To understand the phase transitions, nucleation, growth and deposition.
To experiment various physico-chemical conditions to grow bulk crystals and to deposit films.
To categorize mechanisms involved in crystal growth and in thin film depositions.
To evaluate the growth techniques and to define crystallinity with their merits and challenges.
To modify the existing techniques and to build new techniques to harvest crystals and films with desired properties

UNIT I: Nucleation

Primary nucleation - Secondary nucleation - Solubility, super solubility and metastable zone - Crystal growth theories: surface energy theories, adsorption layer theories, kinematic theories, and diffusion reaction theories.

UNIT II: Crystal Growth from Melt and Vapour

Czochralski method - Bridgmann - Stockbarger method - Zone Melting Method - Vapour growth: direct vapour transport method, Chemical transport method.

UNIT III: Crystal Growth from Solution

Solution and Solubility - Choice of Solvent - Additives - Nucleation - Achievement of Supersaturation - Mason-Jar Method - Holden's Rotary Crystallizer - Temperature Differential Method - growth from silica gel - High temperature solution growth - Flux growth - Top seeded solution growth -Hydrothermal growth.

UNIT IV: Thin Film Deposition: Physical Vapour Deposition

Evaporation method: Vacuum evaporation, Electron beam evaporation - DC diode sputtering, Magnetron sputtering, Reactive ion sputtering, RF sputtering - Pulsed Laser Deposition - Molecular Beam Epitaxy.

UNIT V: Thin Film: Deposition Chemical Vapour Deposition and Liquid Phase Deposition

Chemical vapour deposition - typical chemical reactions - reaction kinetics - transport phenomena - CVD methods – Metal Organic Chemical Vapour Deposition - Plasma enhanced chemical vapour deposition - Langmuir-Blodgett films - Electrochemical deposition - Sol-gel films.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Mullin, W., & Butterworth-Heinemann, (2001). *Crystallization,* (4th Ed.). Oxford.
2. Bhat, H. L. (2015). *Introduction to crystal growth principles and practice.* CRC Press Taylor & Francis Group.
3. Frey, H., & Hamid, R. K. (2015). *Handbook of Thin-Film Technology*. Springer-Verlag Berlin Heidelberg.
4. Cao, G. (2006). *Nanostructures and nanomaterials: synthesis, properties and applications.* Imperial college press, Reprinted.

Unit	Book	Chapters	Sections
I	1	3, 5, 6	3.11, 3.12, 5.1, 5.2, 5.3, 6.1
II	2	8, 10	Relevant topics in page No. 124, 140, 155, 162, 242, 252
III	2	9	Relevant topics in page No. 183, 198, 207, 215
IV	3 2	3, 6, 9 11	3.5, 6.4, 6.6, 6.8, 6.9, 9.4 Relevant topics in page No. 262, 268
V	4 3	5 9	5.5, 5.5.1, 5.5.2, 5.5.3, 5.5.4, 5.9, 5.10, 5.11 9.4

Books for Reference

1. Santhana, P.R, & Ramasamy, P. (2000). *Crystal growth processes and methods.* Kru Publications.
2. Krishna, S. (2002). *Handbook of thin film deposition, processes and techniques,* (2nd Ed.). Noyes Publication.
3. Leon, I. M., & Glang, R (1970). *Handbook of Thin Film Technology.* McGraw Hill Higher Education.

Websites and eLearning Sources*

1. https://en.wikipedia.org/wiki/Thin_film#:~:text=A%20thin%20film%20is%20a,fundamental%20step%20in%20many%20applications**.**
2. https://www.engr.colostate.edu/ECE581/fall07/Two%20dimensional%20structures.pdf
3. https://iisc.ac.in/wp-content/uploads/2017/12/PH351.pdf

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	acquire the knowledge about the fundamentals of nucleation and various crystallization theories.	**K1**
CO2	understand various crystallization theories, various crystal growth methods and thin film deposition techniques.	**K2**
CO3	apply the essential processing parameters for different crystal growth and thin film deposition techniques.	**K3**
CO4	analyze the different growth techniques and choose an appropriate technique to grow crystals and thin films.	**K4**
CO5	evaluate the merits and demerits of different growth techniques	**K5**
CO6	design a new growth approach to overcome the existing demerits.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**							**Hours**	**Credits**
2	**23PPH2SP01B**		**Self-paced Learning:** Physics of Crystal Growth and Thin Films							**-**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	2	2	2	3	**2.5**
CO2	3	3	2	2	2	3	2	2	2	2	**2.2**
CO3	3	3	3	2	2	3	1	2	2	2	**2.3**
CO4	3	3	3	2	2	3	1	2	3	2	**2.4**
CO5	3	3	3	2	2	3	2	2	2	2	**2.4**
CO6	2	3	3	2	2	3	1	2	1	2	**2.1**
Mean Overall Score											**2.23 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2SP01C	**Self-paced Learning:** Ultrasonics and its Applications	-	2

Course Objectives
To know the basics of Ultrasound and its transducers.
To understand the concepts of Ultrasonic measurement techniques.
To apply and realize the ultrasonic imaging in the sonochemistry.
To explore the importance of Non-destructive technique.
To compare various ultrasonic transducers.

UNIT I: Fundamentals of Ultrasonics

Introduction - Brief Early History - Underwater Sound (SONAR) - Medical and Biological Ultrasonics - Industrial Ultrasonics - Nondestructive Testing/Evaluation - Ultrasonics in Electronics - Physical Acoustics - Ultrasonic Systems: Transmitters and Receivers - Low- Intensity Applications - High-Intensity Applications - Modern Ultrasonics: An Interdisciplinary Field - Velocity of Sound in Solids - Velocity of Sound in Liquids - Velocity of Sound in Gases - Wave Incident on a Liquid - Solid Plane Interface, Semi-Infinite Media - Reflection, Refraction.

UNIT II: Basics of Ultrasonic Transducers

Piezoelectric Transducers - equivalent circuit of a simple piezoelectric transducer - efficiency of a simple piezoelectric transducer - maximum power transfer between Electronic Power Source and Simple Piezoelectric Transducers - Determining Transformation Factor (α) for the Piezoelectric Transducer Material - Quality Factor (Q) of Piezoelectric Transducers - Piezoelectric Transducers for High-Intensity Applications - Pulse-Type Transducers for Low-Intensity Applications Sensing - Piezoelectric Polymers for Transducers.

UNIT III: Measurement Techniques of Ultrasonics

Measurement of Velocity and Attenuation in Isotropic Solids - Measurement of Velocity and Attenuation in Fluids - Methods of Measuring Velocity of Sound - Interferometer Method - Resonance Method - "Sing-Around" Method - Pulse-Superposition Method - Pulse-Echo-Overlap Method - Measurements in Materials of High Attenuation - Measurements at High Temperatures - Measurements at High Pressures - Measuring Torsional Resonant Frequencies of Isotropic Bars.

UNIT IV: Applications of Ultrasonics

Electron Acoustic Image Converter - Schlieren Imaging - Liquid Levitation Imaging - Ultrasonic Imaging with Liquid Crystals - Photographic Methods of Imaging by Ultrasonics - Ultrasonic Holography - Acoustic Microscopy - Ultrasonic Arrays - Ultrasound in Process Industries - Monitoring Solidification (Interface Sensing) - Acoustic Time Domain Reflectometry - Three-Phase Reactors - Process Tomography Using Ultrasonic Methods - Ultrasonic Transducers. Process Industry Applications - Sonochemistry - Depolymerization - Polymerization – Precipitation - Metallurgical Effects.

UNIT V: Ultrasonic Non-Destructive Testing

Resonance Methods - Pulse Methods - Acoustic Emission Technique - Factors Affecting Resolution and Sensitivity - Near-Field Effects - Properties of the Materials - Eddy Sonic Inspection Method - Sonic Analysis - Acoustic Impact Technique - Ultrasonic Spectroscopy - Critical Angle Analysis - Instrumentation - Resonance Methods - Pulse Methods - Acoustic Emission Methods - Phased Arrays Systems - Methods Used to Determine Flaw Size.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Dale, E., & Bond, L.J. (2011). *Ultrasonics Fundamentals, Technologies and Applications,* (3rd Ed.). CRC Press, Taylor & Francis Group.

Unit	Book	Chapters	Sections
I	1	1,2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 2.3.1, 2.3.2, 2.3.3
II	1	5	5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.7, 5.3.8, 5.3.9, 5.4.2
III	1	6	6.2.1, 6.2.2, 6.3, 6.3.1, 6.3.2, 6.3.3, 6.3.4, 6.3.5, 6.3.6, 6.3.7
IV	1	10,11	10.2.2, 10.2.3, 10.2.4, 10.2.5, 10.2.6, 10.2.7, 10.2.8, 10.2.9, 10.3.1, 10.3.4, 10.3.5, 10.3.6, 10.3.7, 10.3.8, 11.4, 11.4.1, 11.4.2, 11.4.4, 11.5
V	1	7	7.2.1, 7.2.2, 7.2.3, 7.3, 7.3.1, 7.3.2, 7.4.1, 7.4.2, 7.4.3, 7.4.4, 7.4.5, 7.5, 7.5.2, 7.5.3, 7.5.4, 7.5.5, 7.5.7.2,

Book for Reference

1. David, J., & Cheeke, N. (2002). *Fundamentals and Applications of Ultrasonic Waves*, CRC Press.

Websites and eLearning Sources*

1. http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/usound.html
2. https://www.sonotec.com/en/column/ultrasonic.html
3. https://www.britannica.com/science/ultrasonics
4. (* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	acquire the knowledge of ultrasonic science and technology.	**K1**
CO2	understand the concepts of ultrasound, transducers and its working, measurements and applications.	**K2**
CO3	identify and apply fundamentals of ultrasound, transducers on different measurement techniques and applications of ultrasound.	**K3**
CO4	analyze and discuss basics and applications of ultrasound.	**K4**
CO5	evaluate ultrasonic based measurements, applications and nondestructive testing.	**K5**
CO6	design ultrasonic devices by applying the principles of ultrasound.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PPH2SP01C**			**Self-paced Learning:** Ultrasonics and its Applications						**-**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	2	3	2	3	2	3	2	3	2	1	**2.3**
CO2	3	3	2	2	3	3	2	2	2	1	**2.3**
CO3	3	2	2	3	2	2	3	3	2	1	**2.3**
CO4	3	2	2	3	3	2	2	3	2	1	**2.3**
CO5	3	3	2	2	2	2	2	3	3	1	**2.3**
CO6	3	2	2	3	2	2	3	3	2	1	**2.3**
Mean Overall Score											**2.3 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2SP01D	**Self-paced Learning:** Forensic Physics	-	2

Course Objectives
To study the basic definitions and concepts involved in trace evidences.
To handle the evidences left out at the crime scene.
To Identify the Composition and Manufacture of Glass and Paint.
To Interpret of Physical aspects of Glass evidences.
To analyze the evidences with the help of various spectroscopic methods.

UNIT I: Trace Evidences

Preliminary definitions - Concepts and the production of physical evidence - Uses of trace evidence - The history of trace evidence - The scope of trace evidence - Associations based on physical pattern evidence - Associations based on material comparisons - The role of trace evidence databases - Complementary nature of trace evidence and DNA typing - Recognition and interpretation of trace evidence - Hair and fibre evidence - Glass evidence - Paint evidence - Miscellaneous types of trace evidence - Future Technology and trace evidence - Summary and conclusions.

UNIT II: Composition and Manufacture of Glass

Introduction - Definition of a glass - Commercial glass types - Glass-manufacturing process - Glass - forming processes - Secondary glass processing - Principal glass types and applications.

UNIT III: Interpretation of Physical aspects of Glass evidence

Glass as physical evidence - Recovery of evidence glass fragments - Physical matches of fractured glass - Fractures in flat glass - Fractures in other items - Glass fractures produced by fragments - Backward propagation of glass fragments - Glass in fires - Retention and persistence of glass fragments in clothing - Future directions for the physical examination of glass evidence.

UNIT IV: Interpretation of Paint Evidence

Introduction - Paint transfer mechanisms - Household paints - Vehicle paint - A Bayesian approach - Conclusion.

UNIT V: Elemental Analysis of Glass and Paint

Introduction - Forensic and analytical implications of the composition of glass - Atomic spectroscopy - X-ray methods - Introduction of Infrared spectroscopy - Infrared spectroscopy - Infrared instrumentation - Preparation of samples for analysis - Infrared analysis of paint - Interpretation of IR spectra of non-automotive (domestic) paints - Identification of automotive paints by interpretation of their infrared spectra. EDAX

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Caddy, B. -Taylor & Francis Forensic science series (2001). *Forensic examination of Glass and Paint Analysis and interpretation*, Publication, London, United Kingdom.

Unit	Book	Chapters	Sections
I	1	1	1.1, 1.2, 1.3 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14, 1.15, 1.16
II	1	2	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7
III	1	6	6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7,6.8, 6.9, 6.10
IV	1	12	12.1, 12.2, 12.3, 12.4, 12.5, 12.6
V	1	4,10	4.1, 4.2, 4.3, 4.4, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7

Books for Reference

1. Richard, S., & Tiffany, R. (2020). *Criminalistics -An Introduction to Forensic Science.* Pearson - Education.
2. Hunter, H. (2014). *Solving Crimes with Physics.* Mason Crest publication.

Websites and eLearning Sources*

1. https://www.nist.gov/forensic-science#:~:text=Forensic%20science%20is%20the%20use,to%20anthropology%20and%20wildlife%20forensics.
2. https://www.merriam-webster.com/dictionary/forensic
3. https://nij.ojp.gov/topics/forensics

(* subject to availability – not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	acquire knowledge about the concept and scope of forensic evidences.	**K1**
CO2	understand the composition and manufacturing of different types of evidences.	**K2**
CO3	identify and apply physical aspects of various evidences.	**K3**
CO4	distinguish the different evidences with the help of spectroscopic analysis.	**K4**
CO5	measure the characterization of paint and glass fragments.	**K5**
CO6	integrate the principles and methods of glass and paint evidence.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**						**Hours**	**Credits**
2	**23PPH2SP01D**			**Self-paced Learning:** Forensic Physics						**-**	**2**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	2	2	2	2	**2.4**
CO2	3	3	2	2	2	3	2	2	2	2	**2.3**
CO3	3	3	3	2	2	3	2	2	2	2	**2.4**
CO4	3	3	3	2	2	3	2	2	2	2	**2.4**
CO5	3	3	2	2	2	3	2	2	2	2	**2.3**
CO6	3	3	3	2	2	3	2	2	2	2	**2.4**
Mean Overall Score											**2.36 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2ES03A	**Elective - 3:** Mathematical Methods of Computational Physics and Python Programming	5	4

Course Objectives
To find the different computational techniques for physics applications.
To study the types of elements and symmetry operations and constructing the character tables based on the principles of the group theory.
To solve the differential equation using an appropriate numerical method and root finding methods Constructing a polynomial, like Newton Gregory method for equally spaced points.
To study the modules and structure of python programming.
To study and use the arrays, control structures using python programming.

UNIT I: Basics of Group Theory **(15 Hours)**

Definition and nomenclature - Rearrangement theorem - cyclic groups - subgroups - conjugate elements and class structure - identification of symmetry element and operations - molecular point groups.

UNIT II: Representation of C_n Groups **(15 Hours)**

The Great Orthogonality Theorem (Qualitative treatments) - character of representation. Character table - Generating symmetry operators - construction of character tables - irreducible representation for C_{2v} and C_{3v}.

UNIT III: Numerical Methods Applied to Physics Problems **(15 Hours)**

Numerical integration: Trapezoidal, Simpson's 1/3 rules - Truncation error - composite trapezoidal and Simpson's 1/3 rules. **ODE:** Fourth-order Runge-Kutta methods for first order ODE.

Interpolation: Newton's interpolation - Linear interpolation - Higher-order polynomials - Divided differences - Gregory - Newton forward and backward interpolation formulae - error in interpolation *(no theory and derivation of formulae in the entire unit)*

UNIT IV: Basics of Python **(15 Hours)**

Installing Python - Launch Python - Python modules - Python expression - objects and their methods - Lists - Tuples - Strings - Loops - Development Tools

UNIT V: Python Structure and Control **(15 Hours)**

SciPy and NumPy - arrays - array operations - scripts - contingent behavior - nesting – importing data - exporting data - visualizing data - Functions - random numbers and simulation - histograms and bar graphs - contour plots and surfaces - matrix library - Interpolation - Fourier Transform - Sparse eigenvalue problem.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Joshi, A.W. (2010). *Matrix and Tensors in Physics*. New Age Publications.
2. Tinkham, M. (1974). *Group Theory and Quantum Mechanics*. McGraw Hill Ltd.
3. Venkataraman, M.K. (2013*). Numerical Methods in Science & Engineering*. National Pub. Co. Madras.
4. Jesse, M.K., & Philip, N. (2015). *Python for Physical modelling*. Princeton University Press Princeton and Oxford.
5. https://docs.python.org/3/library/tk.html

Unit	Book	Chapters	Sections
I	1	1 & 2	1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8
II	2	1 & 2, 3, 5	1.1, 1.2, 2.1, 2.3, 2.4, 3.2, 3.3, 3.4, 5.2, 5.3, 5.4
III	3	1,3,7	All sections
IV	4	1, 2	1.2-1.4, 2.1, 2.2.1, 2.3, 2.4
V	4,5	2, 3, 5	2.2.2-2.2.10, 2.5-2.8, 3.1-3.3, 5.1-5.4

Books for Reference

1. Pipes, L. A. & Harvill, L. R (2014). *Applied Mathematics for Engineers and Physicists,* Dover Publications Inc.
2. Arfken, Weber, Harris. (2013). *Mathematical Methods for Physicists,* (7th Ed.). Academic Press.
3. Boas, M.I. (2006). *Mathematical Methods in the Physical Sciences,* (3rd Ed.). John Wiley & Sons.
4. Kreyszig E. (2015). *Advanced Engineering Mathematics, (*10th Ed.). Wiley.
5. Burden, R. L., & Faires, J. D. (2011). *Numerical Analysis,* (9th Ed.). Brooks/Cole Cengage Learning.
6. Chan, J. (2014). *Python for Beginners*.
7. Stewart, A. (2016). *Python Programming*.
8. *NumPy*-1.17 and *SciPy*-1.6.1 reference manual.

Websites and eLearning Sources*

1. https://ocw.mit.edu/courses/mathematics/
2. https://nptel.ac.in/courses/115/103/115103036/
3. https://epgp.inflibnet.ac.in/Home
4. https://swayam.gov.in/explorer
5. http://www.learncodingfast.com/python
6. https://www.tutorialspoint.com/python/index.htm
7. https://www.python.org/

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	remember the: definition of groups, subgroups, Numerical Integration and python modules.	**K1**
CO2	understand the: important properties of group theory and its character tables, numerical integration and python structure.	**K2**
CO3	apply the ideas learnt in the above COs: involving operators and constructing the character tables and numerical interpolation and python functions.	**K3**
CO4	analyse the groups and subgroups, numerical integration and interpolation formulae applied to the physics problems and also using python programs.	**K4**
CO5	evaluate: the groups, numerical problems, Python expression, objects and their methods.	**K5**
CO6	create: the symmetry elements, numerical integration, array operations, scripts, histogram and bar graphs.	**K6**

Relationship Matrix											
Semester	**Course Code**		**Title of the Course**						**Hours**		**Credits**
2	**23PPH2ES03A**		**Elective - 3:** Mathematical Methods of Computational Physics and Python Programming						**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	2	2	3	2	3	1	1	**2.1**
CO2	3	3	2	2	2	3	3	2	1	1	**2.5**
CO3	3	2	3	2	3	2	2	2	3	3	**2.6**
CO4	3	3	2	2	2	3	3	2	1	2	**2.3**
CO5	2	3	3	2	3	2	2	2	3	3	**2.5**
CO6	3	3	2	2	2	3	3	2	1	2	**2.3**
Mean Overall Score											**2.38 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2ES03B	**Elective - 3:** Physics of Disaster Management	5	4

Course Objectives
To impart fundamental knowledge of disasters.
To understand approaches of Disaster Management.
To develop the abilities required for responding to disasters.
To analyze the disaster phenomenon, its different contextual aspects, impacts and public health consequence.
To evaluate the various phases of disaster management of post disasters.

UNIT I: Disaster and its types **(15 Hours)**

Disaster Definition - Geographical Disaster – Flood - Draught, Cyclone - Earthquake - Landslide - Avalanches - Volcanic Eruptions - Climatic Disaster - Heat and Cold Wave - Climate Change - Global Warming - Sea level Rise - zone Depletion.

UNIT II: Manmade Disaster **(15 Hours)**

Manmade Disaster - Nuclear Disaster - Chemical Disaster - Biological Disaster - building Fire - Coal Fire - Oil Fire - Air Pollution - Water Pollution - Industrial Pollution – Deforestation - Rail & Road Accidents - Air & Sea Accidents.

UNIT III: Mitigation and Management techniques of Disaster **(15 Hours)**

Basic principles of disasters management - Disaster Management Cycle - Disaster management policy - National and State Bodies for Disaster Management - Early Warming Systems - building design and construction in highly seismic zones - retrofitting of buildings.

UNIT IV: Study of Important disasters **(15 Hours)**

Earthquakes and its types - magnitude and intensity - seismic zones of India - major fault systems of India plate - flood types and its management - drought types and its management - landside and its managements case studies of disasters in India - Social Economics and Environmental impact of disasters.

UNIT V: Disaster Response **(15 Hours)**

Institutional Arrangements for Disaster Response - Models of Risk Assessment and Disaster Response - Disaster Response in India - Managing and Funding Relief and Recover - Disaster Medicine - Disaster Site Management - Medical and Health Response to Different Disasters - Rehabilitation, Reconstruction and Recovery - Monitoring and Evaluation of Rehabilitation Work - Managing Relief Camps - Disaster Management in India.

Teaching Methodology	Demo Videos, PPT, Handout

Books for Study

Lecture Notes

Books for Reference

1. Copola, D.P. (2006). *Introduction to International Disaster Management* (1st Ed.). Butterworth Heineman.
2. Gupta, A.K., Nair, S.S., & & Chatterjee, S. (2013). *Disaster management and Risk Reduction, Role of Environmental Knowledge.* Narosa Publishing House, Delhi.
3. Murthy, D.B.N. (2012). *Disaster Management.* Deep and Deep Publication PVT. Ltd. New Delhi.
4. Modh, S. (2010). *Managing Natural Disasters*. Mac Millan publishers India LTD.

Websites and eLearning Sources*

1. https://youtu.be/gQxs2VJPf4o
2. https://youtu.be/v-NGndAd0T4
3. https://youtu.be/fZUrR8RA2pI

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	acquire knowledge on basic terms and concepts related to disaster and its management.	**K1**
CO2	understand the importance of disaster and its management.	**K2**
CO3	demonstrate various methods of risk reduction measures and risk mitigation.	**K3**
CO4	analyse the impacts of disasters and their assessment and remedies.	**K4**
CO5	create awareness about disaster prevention and risk reduction.	**K5**
CO6	acquire knowledge on basic terms and concepts related to disaster and its management.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2ES03B**			**Elective - 3:** Physics of Disaster Management					**5**		**4**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	2	2	3	2	3	2	3	2	2	**2.4**
CO2	3	2	3	2	2	2	2	2	3	2	**2.3**
CO3	2	2	2	2	3	3	2	3	2	2	**2.3**
CO4	3	2	2	3	2	3	3	2	3	2	**2.5**
CO5	2	3	2	3	2	2	3	2	2	2	**2.3**
CO6	3	2	2	3	2	3	2	3	2	2	**2.4**
										Mean Overall Score	**2.36 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PSS2SE01	**Skill Enhancement Course:** Soft Skills	4	3

Course Objectives
To provide a focused training on soft skills for students in colleges for better job prospects
To communicate effectively and professionally
To help the students take active part in group dynamics
To familiarize students with numeracy skills for quick problem solving
To make the students appraise themselves and assess others

Unit I: Effective Communication & Professional Communication (12 Hours)

Definition of communication, Barriers of Communication, Non-verbal Communication; Effective Communication - Conversation Techniques, Good manners and Etiquettes; Speech Preparations & Presentations; Professional Communication.

Unit II: Resume Writing & Interview Skills (12 Hours)

Resume Writing: What is a résumé? Types of résumés, - Chronological, Functional and Mixed Resume, Purpose and Structure of a Resume, Model Resume.

Interview Skills: Types of Interviews, Preparation for an interview, Attire, Body Language, Common interview questions, Mock interviews & Practicum

Unit III: Group Discussion & Personal effectiveness (12 Hours)

Basics of Group Discussion, Parameters of GD, Topics for Practice, Mock GD & Practicum & Team Building.

Personal Effectiveness: Self Discovery; Goal Setting with questionnaires & Exercises

Unit IV: Numerical Ability (12 Hours)

Introducing concepts Average, Percentage; Profit and Loss, Simple Interest, Compound Interest; Time and Work, Pipes and Cisterns.

Unit V: Test of Reasoning (12 Hours)

Introducing Verbal Reasoning: Series Completion, Analogy; Data Sufficiency, Assertion and Reasoning; and Logical Deduction. Non-Verbal Reasoning: Series; and Classification

Teaching Methodology	Chalk and talk, Lectures, Demonstrations, PPT.

Book for study

1. Melchias G., Balaiah, J. & Joy, J. L. (Eds). (2018). *Winner in the Making: A Primer on soft Skills.* Trichy, India: St. Joseph's College.

Books for References

1. Aggarwal, R. S. (2010). *A Modern Approach to Verbal and Non-Verbal Reasoning.* S. Chand.
2. Covey, S. (2004). *7 Habits of Highly effective people.* Free Press.
3. Gerard, E. (1994). *The Skilled Helper* (5th Ed.). Brooks/Cole.
4. Khera, S. (2003). *You Can Win.* Macmillan Books.
5. Murphy, R. (1998). *Essential English Grammar*, (2nd Ed.). Cambridge University Press.
6. Sankaran, K., & Kumar, M. (2010). *Group Discussion and Public Speaking* (5th Ed.). M.I. Publications.
7. Trishna, K. S. (2012). *How to do well in GDs & Interview*s? (3rd Ed.). Pearson Education.
8. Yate, M. (2005). *Hiring the Best: A Manager's Guide to Effective Interviewing and Recruiting*

Course Outcomes		
CO No.	CO-Statements On successful completion of this course, students will be able to	Cognitive Levels (K - Level)
CO1	recall various soft skill sets	K1
CO2	understand personal effectiveness in any managerial positions	K2
CO3	apply verbal and non-verbal reasoning skills to solve problems	K3
CO4	differentiate problems at work and home; and design solutions to maintain work-life balance	K4
CO5	assess growth and sustainability and infuse creativity in employment that increases professional productivity	K5
CO6	construct plans and strategies to work for better human society	K6

Relationship Matrix											
Semester	Course Code			Title of the Course				Hours			Credits
2	23PSS2SE01			Skill Enhancement Course: Soft Skills				4			3
Course Outcomes	Programme Outcomes (POs)					Programme Specific Outcomes (PSOs)					Mean Scores of COs
	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2	PSO3	PSO4	PSO5	
CO1	3	3	3	3	2	3	2	3	2	3	2.7
CO2	3	3	3	2	3	3	3	3	3	3	2.9
CO3	3	2	2	3	3	3	3	3	3	3	2.8
CO4	3	3	2	2	3	3	3	3	3	3	2.8
CO5	3	3	3	2	2	3	3	3	3	3	2.8
CO6	3	3	3	2	2	3	3	3	3	3	2.8
Mean Overall Score											2.8 (High)

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2EG01A	**Generic Elective - 1 (WS):** Solar Energy and Utilization	4	3

Course Objectives
To acquire the fundamental knowledge on the solar energy, solar energy conversion and energy storage devices.
To understand the different types of solar radiation measurement, solar cell testing, solar collectors and concentrators, solar thermal systems and energy storage devices.
To apply the concept of energy conversion on different energy storage and solar energy devices.
To identify the merits and demerits of different solar energy devices.
To analyze the various methods used for solar radiation measurement, testing of solar cells, solar energy collector and concentrator, solar thermal systems and energy storage devices.

UNIT I: Solar Energy and insolation **(12 Hours)**

Solar energy - Basic parameters of the Sun - Kelvin-Helmholtz time scale - Energy source of the Sun - Solar Spectrum - Effects of Earth's Atmosphere - Measurement of Irradiance - Solar Simulation.

UNIT II: Photovoltaics **(12 Hours)**

Semiconductor solar cell - Crystalline silicon solar cell - Thin film solar cells - Tandem solar cells - Dye-sensitized solar cells - Bilayer organic solar cells - Solar Cell Testing Methods - The effect of temperature and illumination on cell efficiency - Loss Analysis.

UNIT III: Solar Collectors **(12 Hours)**

Solar Collectors - Flat Plate Collectors - Evacuated-tube collectors - Concentrating Collectors - Optical fundamentals for solar concentration - Parabolic Concentrators - Fresnel lens concentrators - Heliostats.

UNIT IV: Solar Energy Storage **(12 Hours)**

Sensible heat Storage - Phase Transition Chemical Storage - Rechargeable Batteries -Photocatalytic reactions.

UNIT V: Solar Thermal Systems **(12 Hours)**

Solar thermal systems - Water heating for domestic use - water heating for industrial use - Sludge drying - solar distillation - Water Desalination - Food Drying - Water detoxification.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials.

Books for Study

1. Chen, J. (2011). *Physics of Solar energy,* (1st Ed.). Wiley.
2. Alan, L.F., & Bube, R.H. (1983). *Fundamentals of Solar Cells – Photovoltaic Solar Energy Conversion.* Academic Press.
3. Foster, R. (2010). *Solar Energy*. CRC Press.
4. Goswami, Y.D. (2015). *Principles of Solar Engineering*. CRC press.

Unit	Book	Chapters	Sections
I	1 2	1, 2 2	1.1,3.1,3.2,3.3 Chapter-2
II	1 2	9,10 6	9.1, 9.5, 9.6, 9.7, 10.4,10.5 Chapter-6
III	3	4	4.2.1, 4.2.2., 4.2.3.,4.2.3.1., 4.2.3.4., 4.2.4., 4.2.5., 4.2.6.

IV	1 4	12 10	12.1., 12.2.1., 12.3., 12.3.1. – 12.3.4. 10.1
V	3	4	4.4., 4.4.1. – 4.4.5.

Books for Reference

1. Garg. HP (2000), *Solar Energy Fundamentals and Applications*, Tata McGraw-Hill.

Websites and eLearning Sources*

1. https://www.e-education.psu.edu/earth104/node/950
2. https://www.britannica.com/science/solar-energy
3. https://science.sciencemag.org/content/184/4134/382

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements** On successful completion of this course, students will be able to	**Cognitive Levels (K-Level)**
CO1	acquire the knowledge on solar energy and predict its utilization.	**K1**
CO2	understand the concepts of solar insolation and its effects.	**K2**
CO3	apply the concepts of solar energy in the characteristics of different materials like flat plate, tubular, Fresnel etc.	**K3**
CO4	analyze the different energy storage methods, test the solar cells.	**K4**
CO5	assess annual solar savings and its conversion and design the rechargeable batteries.	**K5**
CO6	design solar energy devices for domestic and industrial applications.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2EG01A**			**Generic Elective - 1 (WS):** Solar Energy and Utilization					**4**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	3	2	2	3	3	2	2	2	**2.5**
CO2	3	3	2	2	2	3	3	3	2	2	**2.5**
CO3	3	3	2	2	2	3	3	3	2	2	**2.5**
CO4	3	3	2	2	2	3	3	2	2	2	**2.5**
CO5	3	3	2	2	3	3	3	2	2	3	**2.6**
CO6	3	3	2	2	3	3	3	2	2	3	**2.6**
										Mean Overall Score	**2.53 (High)**

Semester	Course Code	Title of the Course	Hours/Week	Credits
2	23PPH2EG01B	**Generic Elective - 1 (WS):** Renewable Energy Resources	4	3

Course Objectives
To acquire the fundamental knowledge on different types of renewable energy resources and storage systems.
To understand the basic concept of different form of energy conversion.
To apply the fundamental concept of physics into different energy conversion devices.
To identify the merits and demerits of different renewable energy resources.
To analyse the various forms of energy resources based on its reliability and economic aspects.

UNIT I: Direct Solar Energy **(12 Hours)**

Solar Energy supply - History of solar energy utilization - Technologies based on capture of heat from sunlight - Solar water heating system - Solar cookers - Solar steam generating system for cooking - Passive solar heating / cooling of buildings - Solar air conditioning - Solar refrigeration - Solar desalination - Salt production and solar ponds - Crop drying - Technologies for converting solar energy to electricity - Heat engines: Concentrated solar thermal energy systems - Photovoltaics.

UNIT II: Biomass Energy **(12 Hours)**

Composition of biomass - Sources of biomass for energy generation - Food crops - Hydrocarbon - rich plants - Waste - Weed and Wild growths - Lignocellulosic biomass: Fast-growing greases and woody species - Technical routes for obtaining different types of fuels from biomass - Thermochemical conversion of biomass - Biochemical processing - Emerging technologies.

UNIT III: Wind and Wave Energies **(12 Hours)**

Using the wind and power in the wind - Design of windmills - Summary of wind electric energy systems - Wind turbine sizes - Wind sites and properties - Storage - Wave energy generation - Potential energy - Kinetic energy - Wave energy conversion devices - Wave energy conversion by floats - High-level reservoir wave machine - Dolphin-type wave power machine - other wave machines - Advantage and disadvantages of wave energy. Ocean thermal energy conversion.

UNIT IV: Geothermal Energy **(12 Hours)**

Origin and nature of geothermal energy - Energy extraction - High-enthalpy geothermal aquifers - Low-enthalpy reserves - Wet steam systems - Dry steam systems - Limitations.

UNIT V: Storage of Renewable Energy **(12 Hours)**

Energy storage systems - Storage as electrical energy - Storage as mechanical energy - Storage as chemical energy - Storage as thermal energy.

Teaching Methodology	Demo Videos, PPT, Handouts, Study materials

Books for Study

1. Tasneem, A., & Abbasi, S.A. (2010). *Renewable Energy Sources*. PHI Learning Private Limited New Delhi.

UNIT	BOOK	CHAPTERS	SECTIONS
I	1	3	3.2, 3.3, 3.4.1-3.4.9, 3.5.1, 3.5.2
II	1	4	4.3, 4.4.1-4.4.5, 4.5.1-4.5.3
III	1	6	6.3.1, 6.4, 6.5.1, 6.5.2, 6.6, 6.9, 6.10
IV	1	7	7.2.1, 7.2.2, 7.3.1-7.3.4, 7.4.1, 7.4.2

		9	9.1.1, 9.3.1-9.3.4, 9.5
V	1	12	12.2.1-12.2.4

Books for Reference

1. Tiwari and Ghosal (2007), *Renewable energy resources*, Narosa Publishing House.
2. Ramesh R & Kumar K.U (2004), *Renewable Energy Technologies*, Narosa Publishing House.
3. Rai G.D. (2011), *Non-Conventional Energy Sources*, Khanna Publishers.
4. Twidell & Wier (2011), *Renewable Energy Resources*, CRC Press (Taylor & Francis).

Websites and eLearning Sources*

1. https://www.energy.gov/eere/renewable-energy#:~:text=Renewable%20energy%20sources%2C%20such%20as,Bioenergy
2. https://www.un.org/en/climatechange/what-is-renewable-energy
3. https://www.nrdc.org/stories/renewable-energy-clean-facts

(* subject to availability - not to be used for exam purpose)

Course Outcomes		
CO No.	**CO-Statements**	**Cognitive Levels (K-Level)**
	On successful completion of this course, students will be able to	
CO1	acquire the knowledge of physics of solar radiation.	**K1**
CO2	understand the classifications of the solar energy collectors and methodologies of storing solar energy.	**K2**
CO3	know the applications of solar energy, wind energy and biomass and other forms of energy sources.	**K3**
CO4	analysis the different forms of energy resources based on its economic aspects.	**K4**
CO5	assess the generated renewable energies.	**K5**
CO6	design the energy storage systems.	**K6**

Relationship Matrix											
Semester	**Course Code**			**Title of the Course**					**Hours**		**Credits**
2	**23PPH2EG01B**			**Generic Elective - 1 (WS):** Renewable Energy Resources					**4**		**3**
Course Outcomes	**Programme Outcomes (POs)**					**Programme Specific Outcomes (PSOs)**					**Mean Score of COs**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	3	2	3	2	2	2	1	**2.3**
CO2	3	2	3	3	2	3	2	2	2	1	**2.3**
CO3	3	3	3	3	2	3	3	3	2	1	**2.6**
CO4	3	2	3	2	2	3	3	3	2	1	**2.4**
CO5	3	2	3	3	2	3	3	3	2	1	**2.5**
CO6	3	2		3	2	3	3	3	2	1	**2.5**
										Mean Overall Score	**2.43 (High)**