St.Peter's Institute of Higher Education and Research
(Deemed to be University U/S 3 of UGC Act, 1956)
ISO 9001:2015 Certified & NAAC A+ Accredited,
Avadi, Chennai – 600 054. Tamil Nadu.
Phone: 26558080 – 84, Fax: 044 – 26555430.
E-mail: spiher@spiher.ac.in Website: www.spiher.ac.in

M.Sc. (PHYSICS) DEGREE PROGRAMME

(I to IV SEMESTERS)

(REGULATIONS – 2025)

Effective from the Academic Year 2025-2026

DEPARTMENT OF PHYSICS
FACULTY OF SCIENCE
PG PROGRAM (CBCS)

Semester	Course Code	Title of the Course	Course Category	NCrF level	SDG Goal	Instruction Hours / week			Credit(s)	Marks		
						L	T	P		CIA	ESE	Total
I	25PHP101	Mathematical Physics	PCC	6.5	4,9	6	0	0	4	40	60	100
	25PHP111	Advanced Physics Lab I	PCC		4,9	0	0	6	4	40	60	100
	25PHP102	Program Elective I	PEC		4,9	6	0	0	4	40	60	100
	25PHP112	Electronic lab	PEC		4,9	6	0	0	4	40	60	100
	25PHP103	Classical Mechanics and Relativity	PCC		4,9	6	0	0	4	40	60	100
Semester Total						**24**	**0**	**6**	**20**	**200**	**300**	**500**
II	25PHP201	Quantum Mechanics	PCC	6.5	4,9	6	0	0	4	40	60	100
	25PHP211	Advanced Physics Lab II	PCC		4,9	0	0	6	4	40	60	100
	25PHP202	Program Elective II	PEC		4,9	6	0	0	4	40	60	100
	25PHP212	Microprocessor Lab	PEC		4,9	0	0	6	4	40	60	100
	25PHP203	Research Methodology			4,9	6	0	0	4	40	60	100
Semester Total						**18**	**0**	**12**	**20**	**200**	**300**	**500**

Semester	Course Code	Title of the Course	Course Category	NCrF level	SDG Goal	Instruction Hours / week			Credit(s)	Marks		
						L	T	P		CIA	ESE	Total
III	25PHP301	Electromagnetic Theory and Plasma Physics	PCC	6.5	4,9	6	0	0	4	40	60	100
	25PHP302	Program Elective III	PEC		4,9	6	0	0	4	40	60	100
	25PHP311	Microcontroller Lab	PEC		4,9	0	0	6	4	40	60	100
	25PHP381	Internship	SIC		4,9	0	0	6	4	40	60	100
	25PHP391	Mini project	RPC		4,9	0	0	6	4	40	60	100
		VAC-Universal Human Value			4,9	3	0	6	2	40	60	100
Semester Total						**15**	**0**	**18**	**22**	**240**	**360**	**600**
IV	25PHP401	Condensed Matter Physics	PCC	6.5	4,9	6	0	0	4	40	60	100
	25PHP402	Advances in Material Science	PCC		4,9	6	0	0	4	40	60	100
	25PHP491	Project	RPC		4,9	0	0	18	12	40	60	100
Semester Total						**12**	**0**	**18**	**20**	**120**	**180**	**300**

Program Elective –I (Semester I)

CourseCode	Course Title	L	T	P	Credit	Marks		
						CIA	ESE	Total
25PHP102-A	Integrated circuits and Microprocessor 8085	6	0	0	4	40	60	100
25PHP102-B	Non-linear Dynamics	6	0	0	4	40	60	100
25PHP102-C	Crystal growth and Characterization	6	0	0	4	40	60	100
25PHP102-D	Biomaterials Science	6	0	0	4	40	60	100

Program Elective –II (Semester II)

CourseCode	Course Title	L	T	P	Credit	Marks		
						CIA	ESE	Total
25PHP202-A	Medical Physics	6	0	0	4	40	60	100
25PHP202-B	Spectroscopy	6	0	0	4	40	60	100
25PHP202-C	Fibre Optics	6	0	0	4	40	60	100
25PHP202-D	Nano Science	6	0	0	4	40	60	100

Program Elective –III (Semester III)

CourseCode	Course Title	L	T	P	Credit	Marks		
						CIA	ESE	Total
25PHP302-A	8051 Micro controller and Integrated Techniques	6	0	0	4	40	60	100
25PHP302-B	Energy Physics	6	0	0	4	40	60	100
25PHP302-C	Molecular Biophysics	6	0	0	4	40	60	100
25PHP302-D	Electronics in Daily Lifescience	6	0	0	4	40	60	100

25PHP101 **Mathematical Physics** **Semester – I**
6H – 4C

Instruction Hours / week: L: 6 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To understand vector calculus operations and apply integral theorems in various coordinate systems.
- To apply tensor and matrix theory for solving physical and mathematical problems.
- To use complex analysis techniques for evaluating integrals and solving physical problems.
- To study special functions and their properties relevant to differential equations in physics.
- To apply group theory concepts in analyzing molecular symmetry and vibrational spectroscopy.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Evaluate the basic concepts on Mathematical Physics.	K2
CO2	Explain the fundamental concepts of matrices, determinants and their properties.	K1
CO3	Apply residues theorem techniques to solve reals complex integrals in physics problems.	K2
CO4	Derive properties of special functions using differential equations and series solution.	K2
CO5	Analyse symmetry operation and the role in solving differential equation and conserved quantities in physics.	K5

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	-	-	1	1	2	3	2
CO2	3	2	2	-	2	-	-	1	1	2	3	2
CO3	3	2	2	-	2	-	-	1	1	2	3	2
CO4	3	2	2	-	2	-	-	1	1	2	3	2
CO5	3	2	2	-	2	-	-	1	1	2	3	2
AVG	3	2	2	-	2	-	-	1	1	2	3	2

Unit 1: Vector analysis **(12)**

Concept of vector and scalar fields – Gradient, divergence, curl and Laplacian – Vector identities– Line integral, surface integral and volume integral – Gauss theorem, Green's Theorem, Stoke's theorem and applications – Orthogonal curvilinear coordinates – Expression for gradient divergence, curl and Laplacian in cylindrical and spherical co-ordinates - Definitions – Linear independence of vectors – Schmidt's orthogonalisation process – Schwartz inequality.

Unit 2: Tensors and Matrix Theory **(12)**

Transformation of coordinates – Summation convention – Contravariant, covariant and mixed tensors – Rank of a tensor – Symmetric and anti-symmetric tensors – contraction of tensor – Characteristic equation of a matrix – Eigen values and eigenvectors – Cayley – Hamilton theorem- Reduction of a matrix to diagonal form – Jacobi method – Sylvester's theorem.

Unit 3: Complex Analysis (12)

Functions of complex variables – Differentiability -- Cauchy-Riemann conditions – Complex integration – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – Residues and singularities - Cauchy's residue theorem – Evaluation of definite integrals.

Unit 4: Special Functions (12)

Gamma and Beta functions – Sturm- Liouville problem – Legendre, Associated Legendre, Bessel, Laugerre and Hermite differential equations: series solution – Rodriguez formula – Generating functions – Orthogonality relations – Important recurrence relations.

Unit 5: Group Theory (12)

Definition of groups, operations and subgroup- classes-Symmetry operations and elements, Point groups – Matrix representation of a group - Reducible and irreducible representations - Orthogonality theorem – construction of character Table (C2v and C3v) - Application to Infrared and Raman active vibrations of XY2 and XY3 type molecules - Projection operators – Construction of symmetry coordinate for XY2bent symmetric type molecule

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study:

1. A.W. Joshi, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi (1975)
2. Eugene Butkov, Mathematical Physics, Addison Wesley, London (1973)
3. L.A.Pipes and L.R. Harvill, Applied Matematics for Engineers and Physcists, McGraw Hill Company, Signgapore (1967)
4. P.K.Chattopadhyay, Mathematical Physics, Wiley Eastern Ltd., New Delhi (1990)
5. A.K. Ghattak, T.C.Goyal and S.J. Chua, Mathematical Physics, Macmillan, New Delhi (1995)
6. G.Arfken and H.J.Mathemattical Methods for Physicists, 4th ed. *Physicists* (Prism Books, Banagalore, 1995).
7. M.D.Greenberg, Advanced Engineering Mathematics, 2nd ed. International ed., Prentice – Hall International, NJ, (1998)
8. E.Kreyszig, Advanced Engineering Mathematics, 8th ed. Wiley, NY (1999)
9. W.W.Bell, Special Functions for Scientists and Engineers (Van Nostrand, New York, 1968).
10. A.W. Joshi, Elements of Group Theory for Physicists (Wiley Eastern, New Delhi, 1971).
11. F.A. Cotton, Chemical Applications of Group Theory (Wiley Eastern, New Delhi, 1987).

Books for reference:

1. P.R. Halmos, Finite Dimensional Vector Spaces, 2ndEd. (Affiliated East-West, New Delhi, 1965).
2. M. Hamermesh, Group Theory and Its application to Physical Problems (Addison Wesley)
3. C.R. Wylie and L.C. Barrett, Advanced Engineering Mathematics, 6th Ed., International Ed. (McGraw-Hill,NY, 1995).
4. P.K. Chakrabarti and S.N. Kundu, A Text Book of Mathematical Physic (New Central Book Agency,Kolkata, 1996).
5. A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics (Macmillan India, New Delhi, 2002).
6. W.W. Bell, Special Functions for Scientists and Engineers, (Van Nostrand, London, 1968).
7. M.A. Abramowitz and I. Stegun (Editors), Handbook of Mathematical Functions (Dover, Ny, 1972).
8. R.P. Feynman, R.B. Leighton, and M. Sands, The Feynman Lectures on Physics, Vols. 1, 2 and 3 (Narosa, New Delhi, 1998).

Alternative NPTEL / SWAYAM Course

1. https://nptel.ac.in/courses/115103036
2. https://nptel.ac.in/courses/115106086

25PHP111 **Advanced Physics Lab I** **Semester – I**
6H – 4C

Instruction Hours / week: L: 0 T: 0 P: 6

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To make the students familiarize with the basics of experimental physics.
- To enable the students to explore the concepts involved in the thermodynamic processes.
- To make the students understand the properties of magnetic materials
- To make the students calculate and verify experimentally the physical parameters
- To make the students handle the measuring devices

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge of preparation, processing, characterisation and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualise and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show an understanding of the impact of Physics on society and will also be aware of contemporary issues.
PO9: Students will develop confidence for self-education and the ability for lifelong learning.

Course Outcomes (COs)

COs.	Course Outcome	Knowledge level
CO1	Evaluate the basics of experimental physics.	K2
CO2	Explain the concepts involved in the thermodynamic processes	K3
CO3	Derive the properties of magnetic materials	K4
CO4	Demonstrate accurate measurement techniques and execute experimental procedures.	K6
CO5	Analyse experimental data using computational tools and statistical methods to interpret physical properties.	K6

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	1	2	2	3	2	3
CO2	3	3	3	3	3	2	1	2	2	3	2	3
CO3	3	3	3	3	3	2	1	2	2	3	2	3
CO4	3	3	3	3	3	2	1	2	2	3	2	3
CO5	3	3	3	3	3	2	1	2	2	3	2	3

List of Experiments

Advanced Physics

1. Cornu's Method- Young's Modulus and Poison's ratio by elliptic fringes.
2. Stefan's Constant
3. Band gap energy- Thermistor
4. Thickness of the enamel coating on a wire- By diffraction
5. FP Etalon
6. Laser Experiments: Study of Laser beam parameters.
7. Viscosity of liquid – Meyer's disc.
8. Solar spectrum – Hartmann's formula.
9. Arc spectrum – Iron.
10. Edser and Butler fringes – Thickness of air film.
11. B-H loop using Anchor ring.
12. Specific charge of an electron – Thomson's method.

TOTAL HOURS :60

25PHP102-A **Integrated circuits and Microprocessor 8085** **Semester – I 6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Explain the principles and applications of operational amplifiers and linear integrated circuits.
- Describe the working and performance parameters of DAC and ADC systems.
- Analyse combinational and sequential digital circuits, including counters and flip-flops.
- Demonstrate an understanding of 8085 microprocessor architecture, instruction sets, and programming techniques.
- Evaluate interfacing methods for connecting the 8085 microprocessor with digital and analogue peripherals.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Implement analog circuits using operational amplifiers and timers.	K2
CO2	Analyze data conversion techniques using DAC and ADC circuits.	K4
CO3	Design combinational and sequential logic circuits for digital applications.	K1
CO4	Develop assembly language programs for the 8085 microprocessor.	K5
CO5	Interface peripheral devices with the 8085 microprocessor for real-world applications.	K2

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	2	3	3	1	2	1	1	3	1	3
CO2	3	1	2	3	3	1	2	1	1	3	1	3
CO3	3	1	2	3	3	1	2	1	1	3	1	3
CO4	3	1	2	3	3	1	2	1	1	3	1	3
CO5	3	1	2	3	3	1	2	1	1	3	1	3
AVG	3	1	2	3	3	1	2	1	1	3	1	3

Unit I: Linear ICs and Applications **(12)**

Operational amplifier- Solution of simultaneous equations and differential equations- Instrumentation amplifier- Log and Antilog amplifiers- Analog multiplication and division- Generation of square, triangular and sine waves- Pulse

generation- Schmitt trigger- Active filters (Second order Butter worth design)- Timer 555- Internal Architecture and working – Astable and constable multi vibraotrs - Phase Locked Loops (PLL)-PLL in Television Transmitters.

Unit II: Data counters **(12)**

Binary weighted and R/2R ladder DAC- Accuracy and resolution- Dual slope DAC-ADC- Simultaneous conversion-Counter method- Successive approximation.

Unit III: Combinational and Sequential Logic Circuits **(12)**

4-bit binary adder and subtractor- Encoder and decoder- Multiplexer and demultiplexer – Flip Flops- RS, D-type, JK and M/S JK Flip flop, Counters- Asynchronous, synchronous an Modulus counters- BCD counters- Shift registers-Ring counter as divider N counter- Johnson counter as divider 2N counter.

Unit IV: 8085 Programming, Peripheral Devices and their Interfacing **(12)**

Instruction set- Adressing modes- Programming techniques- Memory mapped I/O scheme- I/O mapped I/O scheme-Memory and I/O interfacing- Data transfer schemes- Interrupts of 8085- Programmable pheripheral interface (PPI)-Control group and control word- Programmable DMA controller-Programmable interrupt controller programmable communication interface- Programmable counter /interval timer.

Unit V: 8085 Interfacing Applications **(12)**

Seven-segment display interface- Interfacing of Digital to Analog converter and Analog to Digital converter- Stepper motor interface- Measurement of electrical quantities –Voltage and current) Measurement of physical quantities (Temperature and strain).

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study:

1. R.S. Gaonkar, 1997, Microprocessor Architecture, programming and Application with the 8085, 3rd Edition, Penram International Publications, Mumbai.
2. V. Vijayendran, 2002, Fundamentals of Microprocessor – 8085 - Architecture, Programming and interfacing, Viswanathan Publication, Chennai.

Books for Reference:

1. B. Ram, Fundamentals of Microprocessors and Microcomputers, Dhanpat Rai publications, New Delhi, 2012.
2. R. Theagarajan, S. Dhanasekaran and S. Dhanapal, Microprocessor and its applications, New Age International Publications, New Delhi, 1997.

25PHP102-B **Non-linear Dynamics** **Semester – I** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Understand the fundamental concepts of nonlinear dynamical systems, phase space, and equilibrium classifications.
- Explain the onset of chaos through bifurcations, logistic maps, Lyapunov exponents, and conservative chaotic systems.
- Describe the formation and properties of solitons in nonlinear dispersive systems and related physical phenomena.
- Analyze integrable systems using mathematical tools like Lax pairs, Painlevé analysis, and the Inverse Scattering Transform.
- Evaluate real-world applications of chaos and solitons in communication, condensed matter, optics, and biology.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Analyze nonlinear dynamical systems and classify equilibrium points.	K2
CO2	Interpret chaotic behaviour using bifurcation diagrams and Lyapunov exponents.	K1
CO3	Identify soliton solutions in nonlinear dispersive systems.	K5
CO4	Apply integrability methods to solve soliton equations.	K5
CO5	Explore applications of chaos and solitons in real-world systems.	K1

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	1	1	1	1	3	1	3
CO2	3	3	3	2	2	1	1	1	1	3	1	3
CO3	3	3	3	2	2	1	1	1	1	3	1	3
CO4	3	3	3	2	2	1	1	1	1	3	1	3
CO5	3	3	3	2	2	1	1	1	1	3	1	3
AVG	3	3	3	2	2	1	1	1	1	3	1	3

Unit I (12 hrs)

Introduction to Nonlinear Dynamical Systems The notion of nonlinearity- superposition principle and its validity- linear and nonlinear oscillators- autonomous and nonautonomous systems- equilibrium points- phase space- classification of equilibrium points.

Unit II **(12 hrs)**

Chaos Simple bifurcations- the logistic map- period doubling phenomenon- onset of chaos- bifurcation scenario in Duffing oscillator-chaos in conservative systems: Poincare surface of section- Henon-Heiles systems- Lyapunov exponents.

Unit III **(12 hrs)**

Solitons Nonlinear dispersive systems – Cnoidal and solitary waves- the Scott Russel phenomenon and K-dV equation- Fermi-Pasta-Ulam numerical experiment- Numerical experiment of Zabusky and Kruskal- birth of soliton.

Unit IV **(12 hrs)**

Integrability and methods to solve soliton equations The notion of Integrability – Painleve' analysis- Lax pair- Inverse Scattering Transform method-Bilinearization procedure- examples- Korteweg- de –Vries-Nonlinear Schrödinger equations.

Unit V **(12 hrs)**

Applications – Chaos and secure communications- soliton in condensed matter systems- non linear optics and biological systems.

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study and Reference

1. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics: Integrability Chaos and Patterns, Springer-Verlag, Berlin, 2003.
2. P. G. Drazin, Nonlinear Systems, Cambridge University Press, Cambridge, 1992.
3. P.G. Drazin and R.S. Johnson, Solitons: An introduction Cambridge University Press, Cambridge, 1989.
4. M.J. Ablowitz and P.A. Clarkson, Solitons, Nonlinear Evolution Equations and Inverse Scattering, Cambridge University Press, Cambridge, 1991

Alternative NPTEL / SWAYAM Course

1. https://nptel.ac.in/courses/115106059
2. https://nptel.ac.in/courses/108101002

25PHP102-C **Crystal growth and Characterization** **Semester – I**
6H – 4C

Instruction Hours / week: L: 6 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Understand the principles of phase equilibria and nucleation theories involved in the initial stages of crystal growth.
- Explain the methods and mechanisms of crystal growth from solution, melt, and flux techniques.
- Describe vapor-phase crystal growth methods and epitaxial techniques along with their thermodynamic and kinetic aspects.
- Analyze the influence of various physical and chemical parameters on the growth of high-quality single crystals.
- Evaluate the structural, thermal, and optical properties of grown crystals using standard characterization techniques.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Explain nucleation theories and phase equilibria in crystal growth	K3
CO2	Demonstrate solution-based crystal growth techniques.	K2
CO3	Apply melt growth methods for single crystal formation.	K6
CO4	Describe vapor-phase and epitaxial growth techniques.	K2
CO5	Utilize characterization techniques for analyzing grown crystals.	K4

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	2	3	3	2	2	2	3	3	1	3
CO2	3	2	2	3	3	2	2	2	3	3	1	3
CO3	3	2	2	3	3	2	2	2	3	3	1	3
CO4	3	2	2	3	3	2	2	2	3	3	1	3
CO5	3	2	2	3	3	2	2	2	3	3	1	3
AVG	3	2	2	3	3	2	2	2	3	3	1	3

Unit I Crystal Growth Theory (12 hrs)

Phase equilibria -Single component system - component system - Simple eutectic - Peritectic - Binary compounds with congruent melting - Solid solutions - Solid-liquid and liquid - vapour equilibria. Nucleation concept - Kinds of nucleation - Homogeneous nucleation - Equilibrium stability and metastable state - Classical theory of nucleation - Gibbs-Thomson equation –Kinetic theory of nucleation - Energy of formation of a nucleus - Statistical theory of nucleation - Free energy of formation of nucleus considering translation, vibration and rotation energies.

Unit II Solution Growth (12 hrs)

Growth of crystals from solutions - solvents and solutions – solubility preparation of a olution-saturation and supersaturation-Measurement of supersaturation- Expression for supersaturation- Low temperature solution growth-Slow cooling method - Mason-jar method- Evaporation method-Temperature gradient method - Electro crystallization.Crystal growth in gels - Growth of biological crystals - Crystal growth by hydrothermal methods

Unit III Melt Growth **12 hrs)**

Growth of crystal from melt - Bridgman method - Kyropolous method - Czochralski method-Verneuil method - Zone melting method - LEC growth of III - V materials -Growth of oxide materials. Growth of crystal from flux - Slow cooling method - Temperature difference method - High pressure method - Solventevaporation method - Top seeded solution growth - Growth of superconducting single crystal.

Unit IV Vapor Growth and Epitaxy **12 hrs)**

Methods of vapour phase growth – Physical Vapor Transport (PVT) – Physical Vapor Deposition (PVD) – Chemical Vapor Deposition (CVD) – Chemical Vapour Transport (CVT) – reaction types - thermodynamics, kinetics - transport processes - Thermodynamics of Chemical vapor deposition process – physical, thermo – chemical factors affecting growth process. Epitaxy - Vapour phase Epitaxy (VPE)- Liquid phase epitaxy (LPE)- Molecular Beam Epitaxy (MBE) - Atomic layer Epitaxy (ALE) - Electro epitaxy – Metalorganic Vapour Phase Epitaxy (MOVPE)- Chemical Beam Epitaxy (CBE).

Unit V Characterization methods **(12 hrs)**

Characterization of grown crystals - X-ray Laue, powder diffraction and oscillation photographs - ESCA - SEM and EPMA studies - TGA and DTA to analyses thermal properties - Infrared spectroscopy - Spectrophotometers - Fourier Transforms Interferometer – Sample handling. Raman spectroscopy – Theory - Resonance Raman Spectroscopy - Comparison of Raman with Infrared Spectroscopy.

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study and Reference:

1. K.Sangwal, Elementary Crystal Growth - Saaan Publiser, UK, 1994.
2. M.M. Faktor, I.Garret, Growth of Crystals from Vapor, Chapmann and Hall, 1988
3. P. Santhana Ragavan, P.Ramasamy, Crystal Growth And Processes, KRU Publications, Kumbakonam, 2000
4. P.Ramasamy, ISTE Summer school Lecture Notes, Crystal Growth Centre, Anna University, Chennai, 1991.
5. J.C.Brice, Crystal Growth Process, John Wiley publications, New York,1996
6. A.A.Chernov, Modern crystallography:III,- Crystal Growthin solid state, Springer Series New York,1984.
7. B.R. Pamplin, Progress in Crystal Growth Characterization, Pergamon Press Ltd. (UK)
8. X.F. Zong, Y.Y. Wang, J. Chen, Material and Process Characterization for VLSI, World scientific,New Jersey, 1988.

Alternative NPTEL / SWAYAM Course

1. https://nptel.ac.in/courses/113102108
2. https://nptel.ac.in/courses/113105101
3. https://nptel.ac.in/courses/113104004

25PHP102-D **Biomaterials Science** **Semester – I** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Understand the mechanisms of crystal growth from biological fluids and identify crystals associated with pathological deposits in vivo and in vitro.
- Explain the role of various crystals in joint diseases, including their formation, inflammatory response, and relation to conditions like gout.
- Describe the metabolism and crystallization of calcium pyrophosphate dihydrate and associated arthritic conditions.
- Analyze the relationship between hydroxyapatite and calcium phosphate crystals with degenerative joint diseases such as osteoarthritis.
- Evaluate the biochemical role of steroids and cholesterol in disease conditions, including gallstone formation and lipid disorders

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Identify the role of crystal growth in biological fluids and diseases.	K1
CO2	Analyze the effects of crystal deposition on joints and inflammation.	K2
CO3	Explain the formation and impact of calcium pyrophosphate dihydrate crystals	K2
CO4	Describe the relationship between hydroxyapatite deposition and joint diseases.	K1
CO5	Examine the chemistry, analysis, and medical implications of steroids and cholesterol.	K4

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	2	2	2	3	1	3
CO2	3	3	3	3	3	3	2	2	2	3	1	3
CO3	3	3	3	3	3	3	2	2	2	3	1	3
CO4	3	3	3	3	3	3	2	2	2	3	1	3
CO5	3	3	3	3	3	3	2	2	2	3	1	3
AVG	3	3	3	3	3	3	2	2	2	3	1	3

Unit-I (12 hrs)

Growth from solution - Driving force for crystallization - solubility in biological fluids - Growth kinetics - Nucleation - Diffusion effects - Dissolution - Morphology in vivo & Invitro studies - Crystals responsible for the crystal deposition diseases – Mono sodium urate monohydrate - Calcium pyrophosphate dihydrate - Cholesterol - Steroids - Dicalcium

phosphate dihydrate - Hydroxy apatite- Calcium oxalate - Calcium hydrogen phosphate dihydrate - Lithium heparin crystals.

Unit II **(12 hrs)**

Crystals and joint diseases: Crystal depositon diseases - Deposition of crystals in joints - Crystals induced damage to joints - Crystals and its environment - Mechanism of crystals formation - Induced joint diseases - Actute inflammatory response - Protein binding - Causes for the initiation and termination for the acture inflammation - Chronic inflammation and fibrosis - Destruction of articular cartilage and bone – Gout - Introduction - History - Metabolism of uric acid - hyperuricaemia -Crystallization of urate - Gout crystal – monosodium urate monohydrate - Pathology of gout Unanswered question regarding gout - Other purine disorders associated with crystals.

Unit III **(12 hrs)**

Calcium pyrophosphate dehydrate deposition –Introduction - Pyrophosphate deposition –Metabolism of inorganic pyrophosphate –Crystallization of calcium pyrophosphate dehydrate - Conditions associated with the deposition of calcium pyrophosphate dehydrate crystals – Chronic destructive arthritis – Unanswered questions- Diseases of calcium phosphate deposition:

Unit IV **(12 hrs)**

Introduction - Crystallization of hydroxy apatite - Hydroxy apatite deposition and joints - Relationship between the apatite deposition and osteoarthritis - Other calcium phosphate Miscellaneous crystals and particles - Crystals deposited in synovial joints - Extrinsic crystals and particles found in synovial joints.

Unit V **(12 hrs)**

Steroids - The chemistry of sterols - Analysis of steroids and related Steroids – steroids in biological membranes cholesterol and atherosclerosis - sterol storatge diseases - cholesterol gallstones: Plasma cholesterol in liver disease - solubilization of cholesterol - conditions required for the formation of stones - Bile supersaturated with cholesterol - Origin of biliary lipids - The pathogenesis of supersaturated bile - Secretion rates of biliary lipids - Effect of removing the gallbladder - Medical treatment of gallstones - Dissolution of cholesterol stones by chenodeoxycholic acid - Experimental gallstones in animals – Plasma lipids - lipoproteins – the cause of hypercholesterolemia - Lipid composition of blood cells - Xanthomas in biliary obstruction - parenchymatous liver disease.

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study and Reference:

1. N.B.Myant The Biology of cholesterol and related steroids, William Heinemann Medical Books Ltd, London, 1981.
2. Paul Dieppe & Paul Calvert, Crystals & Joint disease, Chapman and Hall Ltd, London, 1983.
3. Sujata V. Bhat, Biomaterials, Narosa Publising House, New Delhi,2002
4. Albert L.Lehninger, Principles of Biochemistry, CBS, Publishers, India, 1984.
5. Brain R. Pamlin, Inorganic Biological Crystal Growth, Pergamon Press Ltd., UK, 1988
6. A. Ducruix and R.Giege, Crystallization of Nucleic Acids and Proteins A Practical Approach, Oxford University Press, England, 1992

Alternative NPTEL / SWAYAM Course

1. https://nptel.ac.in/courses/113104009
2. https://nptel.ac.in/courses/113108071
3. https://nptel.ac.in/courses/102106057

Semester – I

25PHP112 **Electronics Lab** **6H – 4C**

Instruction Hours / week: L: 0 T: 0 P: 6 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To familiarise the students with the basics of experimental physics.
- To enable the students to explore the concepts involved in Electronics
- To make the students verify experimentally the circuits using devices like Op-Amp, UFT, and FET
- To make the students understand the configuration of the IC chips to perform experiments using appropriate circuits
- To make the students verify experimentally the R-S, J-K, T and D flip-flops

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs.	Course Outcome	Knowledge level
CO1	Evaluate the basics of experimental physics.	K2
CO2	Explain the concepts involved in the Electronics	K3
CO3	Demonstrate the characteristics of Op-Amp, UFT, FET using appropriate test equipment.	K4
CO4	Identify different types of Ic chips and their specifications using datasheets.	K6
CO5	Assemble different types of Flip-flops circuits R-S, J-K, T and D using logic gates on breadboards.	K6

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	1	2	2	3	2	3
CO2	3	3	3	3	3	2	1	2	2	3	2	3
CO3	3	3	3	3	3	2	1	2	2	3	2	3
CO4	3	3	3	3	3	2	1	2	2	3	2	3
CO5	3	3	3	3	3	2	1	2	2	3	2	3

List of Experiments

Advanced Physics (Any Seven)

1. FET CS amplifier- design, Frequency response, input impedance, output impedance
2. Study of attenuation characteristics of Wien's bridge network and design of Wien's bridge oscillator using Op-Amp.
3. Study of attenuation characteristics of Phase shift network and design of Phase shift oscillator using Op-Amp.
4. Designs of Schmitt trigger circuit using IC 741 for a given hysteresis- application as squarer.
5. Study of R-S, clocked R-S and D-Flip flop using NAND/NOR gates
6. Study of J-K, D and T flip flops using IC 7476/7473
7. IC 7490 as scalar and seven segment display using IC7447.
8. Design of UJT relaxation oscillator for a given frequency – Generation of positive and negative triggering pulses.
9. Op-Amp –Active filters: Low pass, High pass and Band pass filters (Second Order) Batter worth filter
10. Construction of square wave generator using IC 555 – Study of VCO.
11. Design of Schmitt trigger circuit using IC555 for a given hysteresis – Application as squarer.
12. Construction of pulse generator using the IC 555 – Application as frequency divider.

TOTAL HOURS :60

25PHP103 **Classical Mechanics and Relativity** **Semester – I 6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Explain Lagrangian and Hamiltonian mechanics and their applications to motion and conservation laws.
- Describe the motion of rigid bodies using Euler's equations and moment of inertia tensor.
- Apply canonical transformations and Poisson brackets to solve equations of motion.
- Analyze small oscillations and determine normal modes in physical systems.
- Explore the principles of special relativity and their applications in physics.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

COs	Course Outcomes	Knowledge level
CO1	Use Lagrangian and Hamiltonian formulations to solve mechanics problems.	K3
CO2	Apply Euler's equations to analyze rigid body dynamics.	K3
CO3	Solve equations of motion using canonical transformation techniques.	K4
CO4	Determine the frequencies of normal modes in oscillatory systems.	K4
CO5	Apply Lorentz transformations and four-vector formulations in relativistic mechanics.	K3

Articulation Matrix (Use only the relevant POs and PSO)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	1	3	2	2	-	-	-	1	2	3	2
CO2	3	1	3	2	2	-	-	-	1	2	3	2
CO3	3	1	3	1	2	-	-	-	2	2	3	2
CO4	3	1	3	2	2	-	-	-	2	2	3	2
CO5	3	1	2	1	2	-	-	-	3	2	3	2
AVG	3	1	2.8	1.6	2	-	-	-	1.8	2	3	2

Unit 1: Lagrangian and Hamiltonian Formulations (12)

Hamiltonian variation principle-Lagrange's equations of motion-Canonical momenta-Cyclic coordinates and conservation of corresponding momenta-Legendre transformation and Hamiltonian-Hamilton's equations of motion-Two-body central force problem-

Kepler problem and Kepler's laws-Scattering by central potential-Two particle scattering-Cross - section in lab frame.

Unit 2: Mechanics of Rigid body **(12)**

Rigid body motion-Kinematics-Euler angles-Infinitesimal rotations-Rate of change of a vector- Carioles force Dynamics-Angular moment a and kinetic energy-Moment of inertia tensor-Euler's equation of motion –Torque free motion-Symmetrical top.

Unit 3: Canonical Transformation **(12)**

Canonical transformations and their generators-Simple examples-Poisson brackets-Equations of motion in Poisson bracket formalism-Symmetries and conservation laws-Hamilton-Jacobi theory- Applications of harmonic oscillator problem.

Unit 4: Small Oscillations **(12)**

Small Oscillations - Eigenvalue problem, Frequencies of free vibrations, Normal coordinates - Applications (Linear triatomic molecule) - forced vibrations and dissipation. Classical Field Theory - Lagrangian and Hamiltonian formalisms for continuous system.

Unit 5: Relativity **(12)**

Lorentz transformations- Four vectors-Lorentz invariance of the four products of two four-vectors-Invariance of Maxwell's equations- Relativistic Lagrangian and Hamiltonian for a free particle.

TOTAL HOURS: 60

SUGGESTED READINGS

Books for Study:

1. H. Goldstein, Classical Mechanics, 3rd Ed., C. Poole and J. Safko (Pearson Eduction Asia Publications, New Delhi, 2002).
2. T.W.B. Kibble, Classical Mechanics, 5th edition, Imperial College Press, 2004.
3. R. Resnick, Introduction to Special Theory of Relativity, Wiley India Pvt Ltd, 2007.

Books for reference:

1. L.D. Landau and E.M. Lifshitz, Mechanics, Pergamon Press, 1969.
2. K.R. Symon, Mechanics, Pearson Publications, 1971.
3. J.L. Synge and B.A. Griffith, Principles of Classical Mechanics, Nabu Press, 2011.
4. S.N. Biswas, Classical Mechanics, Books and Allied publications, Kolkata, 1999.

Alternative NPTEL / SWAYAM Course

1. https://onlinecourses.swayam2.ac.in/ini25_ph03/preview
2. https://onlinecourses.nptel.ac.in/noc25_ph42/preview

25PHP201 **QUANTUM MECHANICS** **Semester – II** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To study the basic concepts of quantum mechanics.
- To understand the different approximation methods used in quantum mechanics.
- To understand the inadequacy of classical physics and the need for quantum theory of radiation and matter.
- To learn the general formalism and the mathematical background of Schrodinger's quantum theory.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Explain the basics of quantum mechanics	K2
CO2	Experiment with quantum states and wave functions using computational tool and analytical method.	K4
CO3	Illustrate the principle of quantum superposition wave functions and probability interpretations using mathematical formalism.	K2
CO4	Construct the appropriate wave functions using variational methods.	K1
CO5	Explain the concepts of Symmetry in Quantum Mechanics	K4

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	2	1	2	3	2
CO2	3	2	2	1	1	1	1	2	1	2	3	2
CO3	3	2	2	1	1	1	1	2	1	2	3	2
CO4	3	2	2	1	1	1	1	2	1	2	3	2
CO5	3	2	2	1	1	1	1	2	1	2	3	2

Unit I: Basic Formalism **(12)**

Interpretations and conditions on the wave function- Postulates of quantum mechanics and the Schrodinger Equation- Ehrenfest's theorem- Stationery states- Hermitian operators for dynamicvariables- Eigen values and eigen functions- Uncertainty principle.

Unit II: One Dimensional Problem and Three Dimensional Problems **(12)**

Particle in a box- Square well potential- Barrier penetration- Simple harmonic oscillator- Ladder operators method- Orbital angular momentum and spherical harmonics-central forces and reduction of two-body problem- Particle in a spherical well – Hydrogen atom.

Unit III: General Formalism **(12)**

Hilbert space- Dirac notation- Representation theory- co-ordinate momentum representations- Time evolution- Schrodinger, Heisenberg and Interaction pictures- Symmetries and conservation laws- Unitary transformations associated with translations and rotations- Parity and time reversal.

Unit IV: Approximation Methods **(12)**

Time –Independent perturbation theory for non-degenerate and degenerate levels- Variation method, simple applications- WKB approximation- Connection formulae (no derivation) – WKB quantization rule- Application to simple harmonic oscillator- Hydrogen molecule, covalent bond and hybridization.

Unit V: Angular Momentum and Identical Particles **(12)**

Eigen value spectrum from angular momentum algebra- Matrix representation- Spin angular momentum- Non-Relativistic Hamiltonian including spin- Addition of angular momenta- Clebsch-Gordan Coefficients- Symmetry and anti-symmetry of wave functions- Spin and Pauli matrices.

TOTAL HOURS: 60

SUGGESTED READINGS

1. P.M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics, McGraw HillEducation, 2010.
2. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, John Wiley, 2009.
3. D. J. Griffiths, Introduction to Quantum Mechanics, 3rd Edition, Cambridge University Press, 2024.
4. G. Aruldhas, Quantum Mechanics, Prentice Hall India Learning, 2008.
5. L.I. Schiff, Quantum Mechanics, 3rd edition, Mc.Graw Hill Education, 1968.
6. E. Merzbacher, Quantum Mechanics Second edition, Willey Publications, 1997.
7. V.K. Thankappan, Quantum Mechanics, 2nd Edition, New Academic Science ltd, 2015.
8. J.L. Powell and B. Crasemann, Quantum Mechanics, Dower Publications, 2015.
9. P.A.M. Dirac, The Principles of Quantum Mechanics, Clarendon Press, 1981.

Alternative NPTEL / SWAYAM Course

1. Quantum mechanics-I https://onlinecourses.nptel.ac.in/noc24_ph15/preview
2. Introduction to Quantum Mechanics https://nptel.ac.in/courses/115104096
3. Quantum Mechanics - An Introduction https://www.youtube.com/watch?v=pGerRhxNQJE

Semester – II

25PHP211 **ADVANCED PHYSICS LAB-II** **6H – 4C**

Instruction Hours / week: L: 0 T: 0 P: 6

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To familiarize the students with Thermal instruments and basic Conductivity Instruments.
- To impart hands-on experience on verification of circuit laws and theorems.
- To understand the basic properties of magnetic materials
- To measure the properties of LASER
- To measure the properties of optical fibers

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Determine Young's modulus and Poisson's ratio using Cornu's method.	K1
CO2	Evaluate the range of beta rays using Feather's analysis with a GM counter	K4
CO3	Perform laser-based diffraction and interference experiments.	K4
CO4	Investigate the properties of optical fibers through experimental analysis.	K1
CO5	Estimate the thermal diffusivity of brass using appropriate techniques.	K2

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	-	2	2	3	2	3
CO2	3	3	3	3	3	2	-	2	2	3	2	3
CO3	3	3	3	3	3	2	-	2	2	3	2	3
CO4	3	3	3	3	3	2	-	2	2	3	2	3
CO5	3	3	3	3	3	2	-	2	2	3	2	3

ADVANCED PHYSICS

1. Cornu's Method – Young's modulus and Poisson's ratio by Hyperbolic fringes
2. GM counter – characteristics, inverse square law, absorption coefficient.
3. GM counter – Feather's analysis: Range of Beta rays.
4. Hall Effect.
5. Susceptibility by Quincke's method.
6. Conductivity measurement using four probe methods.
7. Laser Experiments: (i) Diffraction at straight edge, (ii) Interference of laser beams – Lloyds single mirror method, (iii) Interference using an optically plane glass plate, (iv) Diffraction at a straightwire and (v) Diffraction at a circular aperture.
8. Experiments on optical fibers
9. Thermal diffusivity of brass.

25PHP212 **MICROPROCESSOR LAB** **Semester – II** **6H – 4C**

Instruction Hours / week: L: 0 T: 0 P: 6 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To write programmes for basic mathematical operations using Microprocessor 8085
- To write programmes for sorting of numbers using Microprocessor 8085
- To study serial and parallel interfacing of 8085 microprocessor
- To study the interfacing of Temperature Controller and Measurement
- To study the interfacing of Traffic Light Controller

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Write programmes for basic mathematical operations using Microprocessor 8085	K3
CO2	Executes programmes for sorting of numbers using Microprocessor 8085	K1
CO3	Construct serial and parallel interfacing of 8085 microprocessor	K3
CO4	Operate the perform of Temperature Controller and Measurement	K4
CO5	Evaluate the interfacing of Traffic Light Controller	K6

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	2	3	2	3
CO2	3	3	3	3	3	2	2	2	2	3	2	3
CO3	3	3	3	3	3	2	2	2	2	3	2	3
CO4	3	3	3	3	3	2	2	2	2	3	2	3
CO5	3	3	3	3	3	2	2	2	2	3	2	3

Microprocessor Lab

1. 8-bit addition and subtraction, multiplication and division
2. Sum of a set of N data (8 bit number), picking up the smallest and largest number in an array. Sorting in ascending and descending order.
3. Code conversion (8 bit number): a) Binary to BCD b) BCD to binary.
4. Addition of multi byte numbers, Factorial
5. Clock program- 12/24 hours-Real time application
6. DAC 0800 interface and wave form generation.
7. ADC 0809 interface.
8. Interfacing of DC stepper motor – Clockwise, Anti-clockwise, Angular movement andWiper action.
9. Interfacing of Temperature Controller and Measurement
10. Water level detector.
11. Elevator
12. Traffic Light Controller

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Semester – II

25PHP202-A **MEDICAL PHYSICS** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To understand the applications of physical processes to the diagnosis and treatment of disease, including an understanding of contemporary developments in professional practice.
- To understand the production and use of X-ray, with particular regard to the protection ofpeople and environments.
- To learn the basic principles of ECG, EEG and MRI.
- To acquire technical and research skills to evaluate developments in diagnostic and therapeutic technology.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Explain the principles of bioelectric signals and biosensors.	K1
CO2	Classify different types of transducers and their applications	K2
CO3	Demonstrate methods for measuring blood pressure and heart rate.	K5
CO4	Describe the production, imaging, and applications of X-rays	K5
CO5	Analyze thermographic techniques and the medical applications of lasers.	K2

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	3	3	3	3	3	1	3
CO2	3	2	1	2	2	3	3	3	3	3	1	3
CO3	3	2	1	2	2	3	3	3	3	3	1	3
CO4	3	2	1	2	2	3	3	3	3	3	1	3
CO5	3	2	1	2	2	3	3	3	3	3	1	3

Unit – I Bioelectric Signals **(12)**

Bioelectric Signals – Electrodes – Surface, Needle and Micro Electrodes – Biosensors – PulseSensors.

Unit – II Transducers **(12)**

Thermistors: Photo electric type – transducer – photo voltaic cells – Photo emissive cells – Diode – Detectors – Optical fibers.

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Unit – III Blood Pressure measurements **(12)**

Sphygmomanometer Measurement of heart rate – Basic Principles of EGC – Basic Principles of Electroneurography (ENG) – basic Principles of MRI.

Unit – IV X-rays **(12)**

Basic of X-ray – Production of X-ray – X-ray Image – Applications of X-ray Examinations – Basic Principles of X-ray Tomography.

Unit – V Thermography **(12)**

Endoscopes – Thermography – Liquid Crystal thermography – Microwave thermography – Basic Principles of ultrasonography – Laser – Uses of Lasers in Medicine.

SUGGESTED READINGS

Handbook of Biomedical Instrumentations, TMG, New Delhi (2005) – R.S.Khandpur.

Alternative NPTEL / SWAYAM Course

List the course title

Introduction to Biomedical Imaging systems- https://nptel.ac.in/courses/102105090

Radiation Physics - https://onlinecourses.swayam2.ac.in/ini24_ph03/preview

Semester – II

25PHP202-B **SPECTROSCOPY** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To know the basic physical law that govern molecular spectroscopy
- To Learn the basic information on molecular methods (IR, Raman, UV-VIS, NMR, EPR)
- To be able to select molecular spectroscopy methods suitable for solving given scientific problem.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	**Analyze** the selection rules for Raman and IR vibrational normal modes.	K3
CO2	**Interpret** vibrational spectra using FTIR and ATR techniques.	K1
CO3	**Explain** the principles of Raman scattering and its applications.	K3
CO4	**Describe** the fundamentals of microwave spectroscopy and Stark effect.	K3
CO5	**Apply** NMR, ESR, and Mössbauer spectroscopy in molecular and material analysis.	K4

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	2	3	1	3
CO2	3	3	3	3	3	2	2	2	2	3	1	3
CO3	3	3	3	3	3	2	2	2	2	3	1	3
CO4	3	3	3	3	3	2	2	2	2	3	1	3
CO5	3	3	3	3	3	2	2	2	2	3	1	3

UNIT 1: Normal Co-ordinate Analysis **(12)**

Selection rules for Raman and IR vibrational normal modes – Raman and IR activity (C_{2V} and C_{3V}) point groups – Representation of Molecular Vibrations in Symmetry co-ordinates – Normal coordinate analysis for H_2O molecule, Construction of kinetic constant matrix elements-Wilson's FG matrix method-force constants-potential energy distribution.

UNIT 2: Infrared Spectroscopy **(12)**

FTIR Instrumentation-sampling methods-attenuated Total Internal reflection techniques-Advantages of FTIR-ATR Spectroscopy-Interpretation of vibrational spectra-External factors-internal factors- Hydrogen bonding-coupling of vibrations-Fermi resonance -Electronic effect -Solid state effects- Group vibrations - Finger print regions- Stretching and bending vibrations

UNIT 3: Raman Scattering **(12)**

Vibrational and Rotational Raman spectra – Mutual Exclusion principle – Raman spectrometer-Polarization of Raman Scattering light. Structure Determination through IR and Raman spectroscopy,Phase transitions – Resonance Raman Scattering-A brief description –SERS-CARSS-remote senseRaman Spectroscopy.

UNIT 4: Microwave Spectroscopy **(12)**

Rotational spectra of diatomic molecules – Polyatomic molecules – Linear and symmetric topmolecules – Hyperfine structure and quadrapole moment of linear molecules – Experimental techniques – Stark effect.

UNIT 5: NMR, ESR and MB Spectroscopy **(12)**

Quantum theory of NMR – Bloch equations – Design of CW NMR Spectrometer – Principle andblock diagram of PT NMR – Chemical Shift – Application to molecular structure.Quantum Theory of ESR – Design of ESR Spectrometer – Hyperfine Structure – Anisotropicsystems,Triplet State study of ESR – Applications – Crystal defects-Biological studies, MBS – Briefdescription and application.

SUGGESTED READINGS

1. C. N. Banwell and E. M. McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition TMH, New Delhi.
2. G. Aruldas, 2001, Molecular Structure and Spectroscopy, Prentice Hall of India Pvt, Ltd.New Delhi.
3. D. N. Satyanarayana, 2004, Vibrational Spectroscopy and Applications, New Age International Publication.
4. D. D. Jyaji and M.D Yadav 1991, Spectroscopy, Amol Publications
5. Attaur Rahman, 1986, Nuclear Magnetic Resonance, Spinger Verlag.
6. D. A. Lang, Raman Spectroscopy, Mc Graw- Hill International

Alternative NPTEL / SWAYAM Course

1. Fundamentals of spectroscopy - https://nptel.ac.in/courses/104106122
2. Optical spectroscopy and microscopy - https://nptel.ac.in/courses/102108082
3. Spectroscopic Techniques for Pharmaceutical and Biopharmaceutical Industries - https://onlinecourses.nptel.ac.in/noc24_cy41/preview

Semester – II

25PHP202-C **FIBRE OPTICS** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

CourseObjectives

- To learn the basic elements of the physics of light, optical fiber transmission link, fiber modes configurations and structures**.**
- To understand the different kind of losses, signal distortion, SM fibers.
- To learn the various optical sources, materials and fiber splicing.
- To Gain Knowledge about the fiber optical receivers and noise performance in Photo detector

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Explain the fundamental principles of geometrical, wave, and quantum optics.	K2
CO2	Describe the manufacturing process, advantages, and applications of optical fibers.	K5
CO3	Analyze light propagation in optical fibers, including losses and dispersion.	K5
CO4	Demonstrate measurement and testing techniques for optical fiber performance.	K6
CO5	Illustrate the operation of optical fiber communication devices and components.	K4

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	1	2	-	2	1	2	3	3	1	3
CO2	3	3	1	2	-	2	1	2	3	3	1	3
CO3	3	3	1	2	-	2	1	2	3	3	1	3
CO4	3	3	1	2	-	2	1	2	3	3	1	3
CO5	3	3	1	2	-	2	1	2	3	3	1	3

UNIT-I: Physics of light **(12)**

Geometrical Optics - Speed of light - law of reflection - law of ion - dispersion. Wave/Physicaloptics - amplitude – Wavelength - frequency and velocity - phase and coherence - electromagnetic wave – interference – Diffraction –Polarization - Double refraction. Quantum Optics - probability density of states - atomic spectra - energy levels - lasers and holography (basic ideas only).

UNIT-II: Nature of Optical fibre **(12)**

Manufacturing - advantages and disadvantages - light sources for optical fibres - light emitting diodes - semiconductor lasers - operational parameters - operational setups - fibre jargon - telephone communications - computer network - cable television - fibre optic system examples.

UNIT-III: Light propagation **(12)**

Ray propagation - geometrical optics model - fibre modes - physical optics model - skew rays – alternative paths – characteristics of light. Types of optical fibres – losses – attenuation – dispersion.

UNIT-IV: Optical fibre measurement and testing **(12)**

Equipment used in field testing: optical power meter – cutback method – insertion loss – OpticalTime Domain Reflectometers (OTDR) analysis. Lab measurement techniques: loss due to absorption and scattering – dispersion – core/cladding diameter – index of refractive profile – numerical aperture.

UNIT-V: Operation of devices **(12)**

general theory – characteristics – common detector designs – detector circuitry and devices – splices connectors – cables – couplers and switches – wavelength division multiplexer – fundamentals of communications.

SUGGESTED READINGS

1. Allen H. Cherin: An introduction to Optical fibers, New York: McGraw-Hill (1983)
2. Christian Hentshel: Fiber Optics Handbook, Hewlett – Packard (1984)
3. John M.Senior: Optical fibre communications – Principles and Practice. Prentice Hall International (1985)
4. Donald J.Sterling: Technician's Guide to fibre Optics, Albany, NY Delmar Publishers Inc. (1987)
5. Henry Zanger and Cynthia Zanger: Fibre Optics – communications and other applications, Merrill/Prentice hall (1991)
6. Allen shotwell: An Introduction to Fiber Optics, Prentice- Hall of India private limited, NewDelhi (2004)

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Alternative NPTEL / SWAYAM Course

1. Fiber Optics - https://onlinecourses.nptel.ac.in/noc20_ph07/preview
2. Fiber Optic Communication Technology - https://nptel.ac.in/courses/108106167
3. Fiber-Optic Communication Systems and Techniques- https://onlinecourses.nptel.ac.in/noc19_ee67/preview

Semester – II

25PHP202-D **NANO SCIENCE** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart the basic knowledge on nano science and nanotechnology.
- To develop an understanding on the exotic properties of nanostructure materials.
- To introduce various techniques available for the processing of nanostructured materials.
- To emphasize the importance and development of nanotechnology in various field

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Describe the fundamentals of nanomaterials, including their classification and historical development.	K1
CO2	Explain the synthesis and properties of metal, semiconductor, and ceramic nanocrystals.	K2
CO3	Analyze the magnetic behavior of nanoparticles and their significance in nanoscale magnetism.	K1
CO4	Illustrate the chemical and catalytic aspects of nanocrystals, including their role in catalysis.	K2
CO5	Demonstrate the applications of nanotechnology in various fields, such as electronics, medicine, and structural materials.	K1

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	1	1	2	2	3	1	3
CO2	3	3	2	2	3	1	1	2	2	3	1	3
CO3	3	3	2	2	3	1	1	2	2	3	1	3
CO4	3	3	2	2	3	1	1	2	2	3	1	3
CO5	3	3	2	2	3	1	1	2	2	3	1	3

Unit I Introduction to the Nanoworld: (12)

Introduction – Historical perspective on Nanomaterial - Classification of Nanomaterials – nanorods- nanotubes- nanoparticles - Nanobiotechnology.

Unit II Metals, Semiconductors and Ceramics Nanocrystals (12)

Reduction of size– Synthesis of metal nanoparticles and structures – Routes to arrangements-Background on Quantum Dot semiconductors - background on reverse Micellar solution – Synthesis of Semiconductors – Cadmium Telluride Nanocrystals – Cadmium sulfide Nanocrystals – Alloy Semiconductors – 2D and 3D Superlattices of Silver Sulfide Nanocrystals-Synthesis of Ceramics – Bondings and defects - Chemical, Physical andMechanical properties of Ceramics.

Unit III Nanoparticles and Magnetism (12)

Magnetism in particles of reduced size and dimensions – variations of magnetic moment with size – magnetism in clusters of non magnetic solids – magnetic behavior of small particles – diluted magnetic semiconductors (DMS) – Fe – DMS and IV-VI Mn DMS and their applications – intermetallic compounds – binary and ternaries and their magnetic properties. Importance of nanoscale magnetism.

Unit IV Chemical and Catalytic Aspects of Nanocrystals (12)

Nanomaterials in Catalysis – Nanostructured Adsorbents – Nanoparticles as new Chemical reagents – Nanocrystal Superlattices.

Specific Heats and Melting Points of Nanocrystalline Materials: Specific Heat of Nanocrystalline materials – melting points of Nanoparticle materials.

Unit V Application of Nanotechnology: (12)

Structural and Mechanical materials – Colorants and Pigments – Carbon Nano tubes -Applications – Electronics and magnetic applications- Nano-lithography. Nanobiotechnology – DNA – Chips, DNA array devices, Drug deliverysystems**.**

SUGGESTED READINGS

1. Kenneth J.Klabunde, Nanoscale materials in Chemistry, A John Wiley & Sons, Inc.,Publication, 2001.
2. J.de Jongh, Physics and Chemistry of Metal Cluster Compounds, KluwerAcademicPublishers, Dordrecht, 1994.
3. V. Henrich, P.A.Cox, Metal Oxides, Cambridge University Press, New York, 1994.

Alternative NPTEL / SWAYAM Course

1. Introduction to Nanotechnology- https://nptel.ac.in/courses/118102003
2. Biomedical Nanotechnology- https://onlinecourses.nptel.ac.in/noc25_bt70/preview

Semester – II

25PHP203 **RESEARCH METHODOLOGY** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To familiarize students with the basic concepts and approaches to the study of research.
- To help students to identify the research problem and start asking the right questions with a goal of improving their ability to make a logical argument.
- To assist students to learn various research techniques (qualitative and quantitative).
- To train students in the process of writing various academic and popular writings.
- To sensitize students of research ethics.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Familiar with the basic concepts of science research	K2
CO2	Acquainted with the basics of research methods, techniques and approaches of research.	K4
CO3	Identify the research problem and formulate research questions and hypothesis related to data analysis.	K4
CO4	The process of writing various academic and popular writings.	K3
CO5	Fundamentals of research ethics.	K1

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	2	1	2	1	2
CO2	3	2	2	1	1	1	1	2	1	2	1	2
CO3	3	2	2	1	1	1	1	2	1	2	1	2
CO4	3	2	2	1	1	1	1	2	1	2	1	2
CO5	3	2	2	1	1	1	1	2	1	2	1	2

Unit 1 – Science and Research **(12)**

Definition – History – Evolution of Scientific Inquiry – Verification versus falsification – Objectivity: Facts, theory and concepts – Philosophy of Science and Technology, Epistemology of sciences – Construction of scientific facts.

Unit 2 - Introduction to Research Methodology **(12)**

Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem -Research Design – Need – Features – Inductive, Deductive and Development of models - Developing a Research Plan – Exploration, Description, Diagnosis, Experimentation, Determining Experimental and Sample Designs. -Analysis of Literature Review – Primary and Secondary Sources, Web sources –critical Literature Review - Hypothesis – Different Types – Significance – Development of Working Hypothesis - Research Methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive-Inductive, pattern of Deductive – Inductive logical process – Different types of inductive logical methods.

Unit 3 - Data Collection and Analysis **(12)**

Sources of Data – Primary, Secondary and Tertiary – Types of Data – Categorical, Nominal & Ordinal. - Methods of Collecting Data: Observation, field investigations, Direct studies – Reports, Records or Experimental observations. -Sampling methods – Data Processing and Analysis strategies- Graphical representation – Descriptive Analysis – Inferential Analysis- Correlation analysis – Least square method - Data Analysis using statistical package – Hypothesis testing – Generalisation and Interpretation – Modelling.

Unit 4 – Scientific Writing **(12)**

Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports - Illustrations and tables – Bibliography, Referencing and foot notes – Oral presentation – Planning – Preparation and practice – Making presentation – Use of visual aids – Importance of Effective Communication. Conventions and strategies of Authentication – Citation Style - sheet -Preparing Research papers for journals, Seminars and Conferences – Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN. - Preparation of Project Proposal - Title, Abstract, Introduction – Rationale, Objectives, Methodology – Time frame and work plan – Budget and Justification - References

Unit 5 – Application of Results and Ethics **(12)**

Environmental Impacts - Ethical Issues – Ethical Committees – Commercialization – copy right – royalty – Intellectual Property rights and patent law – Track Related aspects of intellectual property Rights – Reproduction of published material – Plagiarism – Citation and Acknowledgement – Reproducibility and accountability.

SUGGESTED READINGS

1. Garg.B.L., Karadia, R., Agarwal,F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R.(2008). Research Methodology: Methods and Techniques. Second Edition. New Age International Publishers, New Delhi.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270 p.
5. Day RA (1992) How to write and publish a scientific paper. Cambridge University press. London
6. Hempel,C. Philosophy of Natural science Englewood Cliffs, N.J: Prentice Hall, 1966.
7. Burtt, E.A. The Metaphysical Foundations of Modern Science. London, 2003.
8. Latour, B. & Woolgar. 3. Laboratory Life. The construction of scientific facts. 2nd Edition. Princeton: Princeton University Press.1986
9. Gupta S.P. (2008). Statistical Methods. 37th ed. (Rev)Sultan Chand and Sons. New Delhi. 1470 p.
10. Sundar Sarukkai (2008)Indian Philosophy and Philosophy of Science, Motilal Banarsidass Publishers Pvt.Ltd. New Delhi.
11. Kozak A, Kozak R.A., Staudhammer C.L., and Watts S.B. (2008). Introductory probability and Statistics; Applications for forestry and Natural sciences.CAB International, UK.408p.
12. Downine N.M Basic Statistical Methods. New York:¨Harper and Health Row Publishers
13. Frank, Harry. Statistics. Concepts and Applications. Cambridge. Althoen, Steven Cambridge University.

Alternative NPTEL / SWAYAM Course

1. Introduction to Research - https://onlinecourses.nptel.ac.in/noc23_ge36/preview
2. Research Methodology-https://onlinecourses.nptel.ac.in/noc22_ge08/preview

25PHP301 **ELECTROMAGNETIC THEORY AND PLASMA PHYSICS** **Semester – III 6H – 4C**

Instruction Hours/week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To develop theoretical knowledge in electromagnetism and plasma Physics.
- To develop skills on solving analytical problems in electromagnetism and plasma Physics.
- To understand the Maxwell's Equation
- To understand the basics of defining the wave propagation and elementary plasma Physics

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Solve Laplace's equation for boundary value problems in different coordinate systems.	K2
CO2	Demonstrate the concepts of polarization, displacement vectors, and electrostatic energy in dielectrics.	K5
CO3	Apply Biot-Savart's law and Ampere's law to determine magnetic fields for different current distributions.	K4
CO4	Evaluate Maxwell's equations and their implications for wave solutions in different gauges.	K3
CO5	Interpret wave propagation in various media, including conductors and waveguides.	K5

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1	1	2	2	3	2	1	2
CO2	3	3	3	3	3	1	1	2	2	3	2	1	2
CO3	3	3	3	3	3	1	1	2	2	3	2	1	2
CO4	3	3	3	3	3	1	1	2	2	3	2	1	2
CO5	3	3	3	3	3	1	1	2	2	3	2	1	2
AVG	3	3	3	3	3	1	1	2	2	3	2	1	2

Unit I– Electrostatics **(12)**

Boundary value problems and Laplace equation – Boundary conditions and uniquess theorem – Laplace equation in three dimension – Solution in Cartesian and spherical polar co-ordinates – Examples of solutions for boundary value problems. Polarization and displacement vectors – Boundary conditions – Dielectric sphere in a uniform field – Molecular polarisability and electrical susceptibility – Electrostatic energy in the presence of dielectric – Multipole expansion.

Unit II – Magnetostatics **(12)**

Biot-Savart Law – ampere's law – Magnetic vector potential and magnetic field of a localized current distribution – Magnetic moment, force and torque on a current distribution in an external field – Magnetostatic energy – Magnetic induction and magnetic field in macroscopic media – Boundary conditions – Uniformly magnetized sphere.

Unit III – Maxwell Equations **(12)**

Faraday's laws of Induction – Maxwell's displacement current – Maxwell's equations – Vector andscalar potentials – Gauge invariance – Wave equation and plane wave solution – Coulomb and Lorentz gauges – Energy and momentum of the field – Poynting's theorem – Lorentz force – Conservation laws for a system of charges and electromagnetic fields.

Unit IV – Wave Propagation **(12)**

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

Unit V – Elementary Plasma Physics **(12)**

The Boltzman Equation – Simplified magneto-hydrodynamic equations – Electron plasma oscillations – The Debye shielding problem – Plasma confinement in a magnetic field – Magneto- hydrodynamic waves – Alfen waves and magnetosonic waves.

SUGGESTED READINGS

1. D.J. Griffiths, 2002, Introduction to Electrodynamics, 3rd Edition, Prentice-Hall of India, NewDelhi.
1. Walter Greiner, Classical Electrodynamics, 1st edition, Springer, 1998
2. J. R. Reitz, F. J. Milford and R.W. Christy, 1986, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Publication, New Delhi.
3. J. D. Jackson, 1975, Classical Electrodynamics, Wiley Eastern Ltd. New Delhi.
4. J. A. Bittencourt, 1988, Fundamentals of Plasma Physics, Pergamon Press, Oxford
5. W. Panofsky and M. Phillips, 1962, Classical Electricity and Magnetism, Addison Wesley, London.
6. D. Kraus and D. A. Fleisch, 1999, Electromagnetics with Applications, 5th Edition, WCBMcGraw-Hill, New York.
7. B. Chakraborty,2002, Principles of Electrodynamics, Books and Allied, Kolkata.
8. R.P. Feynman, R. B. Leighton and M. Sands, 1998, The Feynman Lectures on Physics, vols.2, Narosa, New Delhi.

Alternative NPTEL/SWAYAM Course

1. https://onlinecourses.nptel.ac.in/noc25_ee149/previewPlasma Physics and Applications
2. https://onlinecourses.swayam2.ac.in/aic21_ge25/preview

Semester – III

25PHP302-A 8051 MICRO CONTROLLER AND INTEGRATED TECHNIQUES 6H – 4C

Instruction Hours/week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the basic building blocks of linear integrated circuits & digital converters.
- To introduce the basics of microprocessor and microcontrollers.
- To acquire knowledge in 8051 instrument set and Assembly language Programming
- To learn the Interrupt Programming

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Implement serial communication in 8051 microcontrollers using different operating modes.	K1
CO2	Identify the hardware components of the 8051 microcontroller and their functions.	K1
CO3	Develop assembly language programs using various instruction sets of the 8051 microcontroller.	K6
CO4	Configure and program interrupts for handling external and internal events in the 8051 microcontroller.	K5
CO5	Interface external devices like LEDs, seven-segment displays, DAC/ADC, and stepper motors with the 8051 microcontroller.	K6

List course outcomes here

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	1	-	2	2	3	2	1	2
CO2	3	2	3	3	3	1	-	2	2	3	2	1	2
CO3	3	2	3	3	3	1	-	2	2	3	2	1	2
CO4	3	2	3	3	3	1	-	2	2	3	2	1	2
CO5	3	2	3	3	3	1	-	2	2	3	2	1	2
AVG	3	3	3	3	3	1	1	2	2	3	2	1	1

Unit I– 8051 Serial Communication **(12)**

8051 connection to R8 2320 – Serial Communication programming – Operating modes – serial port control register – Generating baud rats – Programming 8051 for serial data transfer – Doubling the Baud Rate.

UNIT II: 8051 Microcontroller Hardware **(12)**

Introduction – Features of 8051 – 8051 Microcontroller Hardware: Pin-out 8051, Central Processing Unit (CPU), internal RAM, Internal ROM, Register set of 8051 – Memory organization of 8051 – Input/Output pins, Ports and Circuits – External data memory and program memory: External program memory, External data memory.

UNIT III: 8051 Instruction Set and Assembly Language Programming **(12)**

Addressing modes – Data moving (Data transfer) instructions: Instructions to Access external data memory, external ROM / program memory, PUSH and POP instructions, Data exchange instructions

– Logical instructions: byte and bit level logical operations, Rotate and swap operations – Arithmetic instructions: Flags, Incrementing and decrementing, Addition, Subtraction, Multiplication and division, Decimal arithmetic – Jump and CALL instructions: Jump and Call program range, Jump, Call and subroutines – Programming.

UNIT IV: Interrupt Programming **(12)**

8051 Interrupts – Interrupt vector table – Enabling and disabling an interrupt – Timer interrupts and programming – Programming external hardware interrupts – Serial communication interrupts and programming – Interrupt priority in the 8051: Nested interrupts , Software triggering of interrupt.

UNIT V: Interfacing to External World **(12)**

LED Interface Seven segment display interface- Interfacing of Digital to Analog converter and Analog to Digital converter- Stepper motor interface- Measurement of electrical quantities –Voltage and current) Measurement of physical quantities (Temperature and strain).

SUGGESTED READINGS

1. A. P. Godse and D. A. Godse, “Microprocessors & its Applications”, Technical Publications, Pune.
2. 2. Kenneth Ayala, “The 8051 Microcontroller”, Third Edition, Delmar Cengage Learning,2005
3. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mckinlay, “The 8051 Microcontroller and Embedded Systems”, Second Edition, Pearson Education 2008.
4. W. A. Triebel and Avatar Singh, The 8086/8088 Microprocessors – Programming. Software, Hardware and Application, Prentice Hall of India, New Delhi, (Unit 2).
5. Douglas V. Hall: - Microprocessors and Interfacing programming and Hardware (Tata Mc Graw Hill) (Unit 1)
6. B, Brey, 1995, Intel Microprocessors 8086/8088, 80186,80286,80486,80486, Architecture, Programming and Interfacing
7. Yu – Cheng and Glenn A. Gibson, The 8086/ 8088 family Architecture, Programming and Design, Prentice-Hall of India.
8. Muhammed Ali Mazidi and Janice Gillespie Mazidi, 2004, The 8051 Microcontroller and Embedded systems, Fourth Indian Reprint, Pearson Education.

Alternative NPTEL/SWAYAM Course

1. https://nptel.ac.in/courses/108105102Microprocessors and Microcontrollers
2. https://nptel.ac.in/courses/108105102

Semester – III

25PHP302-B **ENERGY PHYSICS** **6H – 4C**

Instruction Hours/week: L: 6 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To have an insight on the various renewable energy resources available at a location and assessment of its potential, using tools and techniques.
- To learn about the solar energy radiation, its interactions, measurement and estimation.
- To acquire knowledge in Geothermal, wave, tidal resources and site selection.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Explain the availability and potential of various energy sources, with a focus on renewable energy.	K1
CO2	Measure and analyze solar radiation data for different surface orientations.	K2
CO3	Characterize different types of solar cells and evaluate their efficiency.	K1
CO4	Assess wind energy potential and describe wind energy conversion systems.	K2
CO5	Differentiate biomass conversion technologies and describe the functioning of biogas plants.	K1

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	3	3	2	2	3	2	1	2
CO2	3	2	-	-	-	3	3	2	2	3	2	1	2
CO3	3	2	-	-	-	3	3	2	2	3	2	1	2
CO4	3	2	-	-	-	3	3	2	2	3	2	1	2
CO5	3	2	-	-	-	3	3	2	2	3	2	1	2
AVG	3	2	-	-	-	3	3	2	2	3	2	1	1

Unit I: Introduction to energy sources **(12)**

Energy sources and their availability – prospects of renewable energy sources.

Solar radiation and its measurements **(12)**

Solar constant – solar radiation at the Earth's surface – solar radiation Geometry – solar radiation measurements – solar radiation data – estimation of average solar radiation – solar radiation of tilted surfaces.

Unit II Solar cells **(12)**

Solar cells for direct conversion of solar energy to electric powers – Solar cell parameter – Solar cell electrical characteristics – Efficiency – Single crystal silicon solar cells – Polycrystalline silicon solar cells – cadmium sulphide solar cells.

Unit III Applications of solar energy **(12)**

Solar water heating – space heating and space cooling – solar photo voltaics – agricultural and industrial process heat – solar distillation – solar pumping – solar furnace – solar cooking – solar green house.

Unit IV Wind Energy **(12)**

Base principles of wind energy conversion wind data and energy estimation – Base components of wind energy conversion systems (WECS) types of wind machines – Generating systems – schemes for electric generation – generator control – load control – applications of wind energy.

Unit V Energy from Biomass **(12)**

Biomass conversion Technologies – wet and Dry process – Photosynthesis.

Biogas generation: Introduction – basic process and energetic – Advantages of anaerobic digestion – factors affecting bio digestion and generation of gas. **Classification of Biogas plants:** Continuous and batch type – the done and drum types of Bio gas plants – biogas from wastes fuel properties of biogas utilization of biogas.

SUGGESTED READINGS

1. Kreith and Kreider, Principles of solar Engineering, 2nd Edition, 2008, Mc Graw HillPub.,
2. A.B.Meinel and A.P.Meinel, Applied Solar Energy, 1976, Addison WeselyEducation Publishers, India.
3. M.P.Agarwal, Solar Energy, S.Chand & Co., 1983.
4. S.P.Sukhatme, Solar Energy, Tata McGraw Hill Publications, 1984.
5. G.D.Rai, Non-conventional Energy sources, Khauna Publications, Delhi, 2004.

Alternative NPTEL/SWAYAM Course

1. https://onlinecourses.nptel.ac.in/noc25_ch58/preview
2. https://nptel.ac.in/courses/103107157

25PHP302-C **MOLECULAR BIOPHYSICS** **Semester – III** **6H – 4C**

Instruction Hours / week:L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide a foundation in the basic concepts of Biophysics.
- To learn canonical and non-canonical structures of nucleic acids, proteins, enzymes etc.
- To have insight on the basics of diffusion, thermodynamics and kinetics in context of biological processes.
- To understand the fundamental concepts that underlie biomolecular interactions and biological methods.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Describe the structural and molecular components of prokaryotic and eukaryotic cells.	K2
CO2	Analyze molecular interactions, weak forces, and their role in macromolecular stability.	K6
CO3	Explain nucleic acid and protein structures, including DNA polymorphism and virus structure.	K6
CO4	Explain the principles and techniques of X-ray protein crystallography for molecular structure determination.	K4
CO5	Apply thermodynamic principles to biological systems, including genetic information transfer and protein biosynthesis.	K5

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	2	2	2	2	3	2	1	2
CO2	3	3	2	1	1	2	2	2	2	3	2	1	2
CO3	3	3	2	1	1	2	2	2	2	3	2	1	2
CO4	3	3	2	1	1	2	2	2	2	3	2	1	2
CO5	3	3	2	1	1	2	2	2	2	3	2	1	2
AVG	3	3	2	1	1	2	2	2	2	3	2	1	1

Unit-I Cell: Its organelles and molecules **(12)**

Basic structure of prokaryotic and eukaryotic cells–mitochondria and the generation of ATP– Chemical composition of living systems – molecular components of cell – chemical structure of carbohydrate– Lipids-proteins– Nucleic acids–hetero macromolecules.

Molecular interactions

Molecular forces–forces hold macromolecules together–intermolecular weak forces-van der waals-inductive force-dispersion force-Lenard-Jones potential-hydrogen bond – hydrophobic forces-acid, bases and pH, pK, pl and buffering.

Unit-II Macromolecular Structure **(12)**

Nucleic acid structure–conformation of monomers and polymers–double helical structure of DNA–polymorphism of DNA–DNA super coiling – structure of transfer RNA. Protein structure–amino acids–primary structure–peptide bond–secondary structure – α-helix and β- sheet-tertiary and quaternary structure – Virus structure.

Unit-III X-ray Protein Crystallography **(12)**

Crystals and symmetries–crystal system–Pont groups–space groups– Preparing Protein samples – protein crystal growth–X-ray sources– diffraction–data collection and data reduction–computational techniques– Phase problem–Patterson function–Fourier technique–Isomorpous replacement –molecular replacement–Anomalous scattering – refinement– fitting maps.

Unit-IV Physics of Bio-membranes and Enzymes **(12)**

Cell membrane –structure of cell membrane – membrane asymmetry – transport through membrane-active transport–Passive transport– transport of charged particles. Enzymes: Chemical Kinetics and catalysis – Enzymatic reactions– Chemical aspect of enzymatic action–conformation of enzyme–Physics of enzyme-substrate interactions.

Unit-V Molecular thermodynamics **(12)**

Equilibrium thermodynamics – near equilibrium thermodynamics- Gibbs free energy – chemical potential – thermodynamic analysis of membrane transport – phase equilibrium – irreversible thermodynamics.

Molecular mechanism of genetic information transfer

Genetic code – transmission of genetic information – molecular mechanism of Protein synthesis-transcription – translation – recognition of Amino acids – Protein Biosynthesis-principle of molecular recognition – intercellular interaction.

SUGGESTED READINGS

1. Molecular Biophysics –Structure in motion- M. Duane; Oxford University Press, 1999.
2. Introduction to Molecular Biophysics – J. A. Tuszynski and M. Kurzynski, CRC Press Publications, 2003.
3. Principles of Physical Biochemistry- K.E. Van Holde, N.C. John and P.S. HoPrentice Hall Publications
4. Biophysics – M. V. Volkenshtein ; 1st Edition, 1983, Mir Publications , Moscow.
5. Biophysical Chemistry, Part I. The conformation of Biological macromolecules, Part II.Techniques for the study of biological structure and function, Part III.The behavior of biological macromolecules; C. R. Cantor and P.R. Schimmel;1980,Publications W.H. Freeman
6. Practical Protein Crystallography- Duncan E. McRee- 2nd Edition, 1999, Academic PressPublications.
7. Biophysics An Introduction – Rodney M. J. Cotterill; John Wiley Publication, 2002.
8. Biophysics – Vasantha Pattabhi and N.Gautham; 2nd Edition, 2011, Narosa Publishing House
9. Biophysics – Roland Glacer; 2nd Edition, 2012, Pringer Publications
10. Elementary Biophysics An Introduction – P. K. Srivastava ; 2nd Edition, 2011, Narosa Publishing House.

Alternative NPTEL/SWAYAM Course

1.Cellular biophysics: a framework for quantitative biology

2.Molecular Biology

Semester – III

25PHP302-D **ELECTRONICS IN DAILY LIFE** **6H – 4C**

Instruction Hours / week:L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To enhance comprehension capabilities of students through understanding of electronicdevices.
- To give clear understanding of operational amplifier and its importance.
- To understand the physical construction, working and operational characteristics of semiconductor devices.

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Explain the fundamental electronic components, symbols, and electrical quantities.	K4
CO2	Identify and explain the working principles of common electrical appliances.	K2
CO3	Analyze the function and operation of electronic home appliances.	K2
CO4	Explain the basics of communication electronics, including Optical fiber cables, telephones, and mobile networks.	K1
CO5	Apply safety mechanisms for handling electrical and electronic devices, power-saving techniques, and hazard prevention.	K1

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	2	3	3	3	2	1	2
CO2	3	3	2	2	2	2	2	3	3	3	2	1	2
CO3	3	3	2	2	2	2	2	3	3	3	2	1	2
CO4	3	3	2	2	2	2	2	3	3	3	2	1	2
CO5	3	3	2	2	2	2	2	3	3	3	2	1	2
AVG	3	3	2	2	2	2	2	3	3	3	2	1	1

UNIT – I Basics of Electronics **(12)**

Electrical and Electronic Symbols Resistors – Capacitors – Resistance wale – Capacitorwale – Electrical quantities – Electrical formulas – Magnetism – Meters – Fuse wire Transistors – Integrated chips

UNIT – II Electrical appliances **(12)**

Switch board – Main box – Metal circuit breakers (MCB) – AC – DC currents – Two Phase Three Phase electrical connections – generators – un intrepid power supply (UPS)- stabilizer – voltage regulators – Electrical devices – Iron box – Fan – Electrical Oven – water Heaters Air conditionRefrigerators – washing machines

UNIT – III Electronic home appliances **(12)**

Radio – Audio taper veaulem, speaker- televisions – VCR – CD Players – DVD – calculators Computers – scanner – Printer – Digital Camera – LCD Projectors – Display devices

UNIT – IV Communications Electronics **(12)**

Principles of optical fiber Cables (OFC) – Telephone – Mobile phones – wireless phone -Antenna - Internet - Intranet

UNIT - V Safety Mechanisem **(12)**

Handling Electrical appliances - Power saving methods - Hazards Prevention Methods -Protection of Hi –Fi- electronic devices.

SUGGESTED READINGS

1. S.S. Kamble – Electronics and Mathematics Data book – Allied publishers Ltd –1997

Alternative NPTEL/SWAYAM Course

1. https://onlinecourses.swayam2.ac.in/ntr25_ed130/preview

Semester – III

25PHP311 MICROCONTROLLER LAB 6H – 4C

Instruction Hours/week : L: 0 T: 0 P: 6 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Study assembly language programs for various applications using 8051 microcontroller
- Write assembly language programs for basic arithmetic operations using 8051 microcontroller
- Write assembly language programs for sorting of numbers using 8051 microcontroller
- Write assembly language programs for interfacing seven segment display using 8051 microcontroller
- Write assembly language programs for interfacing seven segment display, traffic light controller etc., using 8051 microcontroller

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.

PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics

PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.

PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.

PO6: Students will demonstrate knowledge of professional and ethical responsibilities.

PO7: Students will be able to communicate effectively in both verbal and written form.

PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.

PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Perform arithmetic operations and series computations using microcontroller programming.	K1
CO2	Implement data manipulation techniques such as block transfer and multi-byte operations.	K4
CO3	Develop sorting algorithms to organize numerical data efficiently.	K4
CO 4	Interface LEDs and seven-segment displays for real-time counting applications.	K1
CO5	Generate analog waveforms using DAC and acquire data using ADC modules.	K2

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	-	2	2	3	2	1	2
CO2	3	3	3	3	3	2	-	2	2	3	2	1	2
CO3	3	3	3	3	3	2	-	2	2	3	2	1	2
CO4	3	3	3	3	3	2	-	2	2	3	2	1	2
CO5	3	3	3	3	3	2	-	2	2	3	2	1	2
AVG	3	3	3	3	3	2	-	2	2	3	2	1	1

Microcontroller Lab

1. Addition, Subtraction, Multiplication and division of two 8-bit numbers.
2. Sum of a series of 8-bit numbers,
3. Average of N numbers.
4. Factorial of number.
5. Fibonacci series of N terms.
6. Block Move Transfer.
7. Multi byte Addition / Subtraction.
8. Sorting in ascending and descending order – Picking up smallest and largest number.
9. LED interface – Binary up/down counter, BCD up/down counter, Ring and twisted ring counter.
10. Interfacing seven segment displays.
11. DAC 0800 / 1408 interface and wave form generation.
12. ADC interfacing.
13. Stepper motor interfacing.
14. Temperature controller and Measurements.
15. Traffic light controller
16. Elevator

Course Code	Course Title	L T P C
	UNIVERAL HUMAN VALUES (UHV)	**2 0 0 2**
Prerequisites : None		

Course Objectives:

1. To examine the importance, scope, and methodology of value education in achieving holistic human development
2. To foster deeper understanding and application of human relationships, harmony, and ethical behavior across multiple levels of living.
3. To interpret the role of harmony in human existence—including self, family, society, and nature.
4. To link human values with responsible professional behavior and leadership.
5. To implement strategies for value-based personal and professional decision-making.

Unit 1: Introduction to Value Education **Hours: 6**

Concept of Right Understanding, Relationship, and Physical Facility – Holistic Development and the Role of Education – Significance of Value Education – Self-Exploration as a Rigorous Method – Human Aspirations: Happiness and Prosperity – Discrepancies in the Current Scenario – Framework to Achieve Basic Aspirations.

Unit 2: Harmony in the Human Being **Hours: 6**

Human Being as the Coexistence of Self and Body – Analysis of Needs: Self vs. Body – Body as a Tool for Realization – Self-Regulation through Right Understanding – Health and Well-being through Inner Harmony-Neuroscience of Mind-Body Connection in Emotional Regulation

Unit 3: Harmony in Family and Society **Hours: 6**

Family as the Basic Unit – Trust and Respect: Evaluation and Practice – Justice and Mutual Fulfilment – Social Structures and Values – Principles of the Universal Human Order – Ethical Decision-Making in Relationships.

Unit 4: Harmony in Nature and Existence **Hours: 6**

Ecological Perspective: Four Orders in Nature – Interdependence and Self-regulation – Realizing Existence as Co-existence at All Levels - Viewing Existence as Coexistence – Understanding Sustainability and Ecological Ethics – Integrating Harmony in Professional Outlooks.

Unit 5: Holistic Understanding and Professional Ethics **Hours: 6**

Natural Acceptance of Values – Human Conduct and Ethical Frameworks – Education and Constitutional Principles – Ethical Leadership – Value-based Technologies and Organizational Practices – Strategic Models for Sustainable Living.

Text Books:

1. Gaur, R.R., Sangal, R., & Bagaria, G.P., A Foundation Course in Human Values and Professional Ethics, Publisher: Excel Books, New Delhi, 2022.
2. Sharma, S. B., Education for Values, Environment and Human Rights, Publisher: Lotus Press, New Delhi, 2022
3. Pathania, A. , Value Education: Perspectives and Practices, Pearson Education India, 2023
4. The Textbook A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034- 47-1

Reference Books:

1. Schumacher, E.F. , Small is Beautiful: A Study of Economics as if People Mattered, Random House UK / Vintage publisher, 2022
2. Dhar, P.L. & Gaur, R.R, Science and Humanism, Publisher: Commonwealth Publishers, New Delhi, 2023
3. Sharma, R.N., Human Values and Professional Ethics, Kalyani Publishers, 2022

Websites:

1. http://www.mhrd.gov.in – Ministry of Education, Govt. of India.
2. http://www.uhv.org.in – Universal Human Values initiative.
3. https://www.aiu.ac.in – Association of Indian Universities: Value Education resources.

Course Outcomes:

CO1: Demonstrate understanding of the holistic development of a human being.

CO2: Distinguish between physical needs and the needs of the self.

CO3: Apply human values in family and societal interactions.

CO4: Analyze nature and existence in terms of mutual harmony and co-existence.

CO5: Integrate ethical human conduct in their professional practice.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	–	–	–	–	–	3	2	2	2	–	–	1
CO2	–	–	–	–	–	3	1	2	2	–	–	1
CO3	–	–	–	–	–	3	3	3	2	–	–	2
CO4	–	–	–	–	–	2	1	3	2	–	–	2
CO5	–	–	–	–	–	3	2	2	3	–	–	3

25PHP401 **Condensed Matter Physics** **Semester – IV** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

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

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Analyze crystal structures, diffraction conditions, and various types of crystal binding.	K3
CO2	Explain lattice vibrations, phonon interactions, and thermal properties of solids	K1
CO3	Apply band theory to metals and semiconductors and examine electronic transport properties	K3
CO4	Interpret different types of magnetism and their quantum mechanical foundations.	K4
CO5	Evaluate superconducting phenomena and their theoretical models, including BCS theory and Josephson effects.	K5

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	2	2	3	2
CO2	3	3	3	3	3	2	2	2	2	2	3	2
CO3	3	3	3	3	3	2	2	2	2	2	3	2
CO4	3	3	3	3	3	2	2	2	2	2	3	2
CO5	3	3	3	3	3	2	2	2	2	2	3	2

Unit I – Crystal Physics **(12)**

Types of lattices – Miller indices – Symmetry elements and allowed rotations – Simple crystal structures- Atomic Packing Factor – Crystal diffraction – Bragg's law – Scattered Wave Amplitude – Reciprocal Lattice (sc, bcc, fcc) – Diffraction Conditions – Laue equations – Brillouin zone –Structure factor – Atomic form factor – Inert gas crystals – Cohesive energy of ionic crystals – Madelung constant – Types of crystal binding (general ideas)

Unit II – Lattice Dynamics **(12)**

Lattice with two atoms per primitive cell – First Brillouin zone – Group and phase velocities – Quantization of lattice vibrations – Phonon momentum – Inelastic scattering by phonons – Debye's theory of lattice heat capacity – Thermal Conductivity – Umkalapp Process.

Unit III – Theory of Metals and Semiconductors **(12)**

Free electron gas in three dimensions – Electronic heat capacity – Wiedemann-Franz law – Band theory of metals and semiconductors – Bloch theorem – Kronig-Penny model – Semiconductors – Intrinsic carrier concentration – Temperature Dependence – Mobility – Impurity conductivity – Impurity states, Hall effect – Fermi surfaces and construction – Experimental methods in Fermi surface studies – de Hass-van Alphen effect.

Unit IV – Magnetism **(12)**

Diamagnetism – Quantum theory of para magnetism – Rare earth ion – Hund's rule – Quenching of orbital angular momentum – Adiabatic demagnetization – Quantum theory of ferromagnetism – Curie point – Exchange integral – Heisenberg's interpretation of weiss field – Ferromagnetic domains – Bloch wall – Spin waves – Quantization – Magnons – Thermal excitation of magnons – Curie temperature and susceptibility of ferri magnets – Theory of anti ferromagnetism – Neel temperature.

Unit V – Superconductivity **(12)**

Experimental facts: Occurrence – Effect of magnetic fields – Meissner effect – Critical field – Critical current – Entropy and heat capacity – Energy gap – Microwave and infrared properties – Type I and II superconductors, Theoretical Explanation: Thermodynamics of super conducting transition – London equation – Coherence length – Isotope effect – Cooper pairs – BCS Theory – Single particle tunneling,Josephson tunneling – DC and AC Josephson effects – High temperature superconductors – SQUIDS.

SUGGESTED READINGS

Books for study:

1. N. W. Aschroft and N. D. Mermin, Solid State Physics, Rhinehart and Winton, New York, 1976.
2. J. S. Blakemore, 1974, Solid state Physics, 2nd Edition, W. B. Saunder, Philadelphia
3. A. J. Dekker, Solid State Physics, Macmillan India, New York
4. H. M. Rosenburg, 1993, The Solid State, 3rd Edition, Oxford University Press, Oxford.
5. S. O. Pillai, 1997, Solid State Physics, New Age International, New Delhi. International, New Delhi.
6. S. L. Altmann, Band Theory of Metals, 2013, Pergamon Publications, Oxford.
7. J. M. Ziman, 1971, Principles of the Theory of solids, Cambridge University Press, London.
8. C. Ross-Innes and E. H. Rhoderick, 1976, Introduction to Superconductivity, Pergamon, Oxford.
9. M. Tinkham, Introduction to Superconductivity, 2nd Edition, 2004, McGraw-Hill, New York.
10. J. P. Srivastava, 2001, Elements of Solid State Physics, Prentice-Hall of India, New Delhi.

Books for reference:

1. J.C. Anderson, K.D. Leaver, R.D. Rawlings, Material Science, Van Nortrand Reinhold Publications, 1990.
2. Alexander, Materials Science, 4th Edition, Chapman-Hall, London, 1990.
3. J.S. Blakemore, Solid State Physics, 2nd Edition, W.B.Saunder, Philadelphia, 1974.
4. A.J. Dekker, Solid State Physics, Macmillan India Publications.
5. H.M. Rosenburg, The Solid State, 3rd Edition, Oxford University Press, Oxford, 1993.
6. C.M. Kachhava, Solid State Physics, Tata McGraw- Hill, New Delhi, 1990.
7. S.O. Pillai, Solid State Physics, New Age International, New Delhi, 1997.

Alternative NPTEL / SWAYAM Course

1. https://nptel.ac.in/courses/115106061
2. https://nptel.ac.in/courses/115103102

25PHP402 | **Advances in Material Science** | **Semester – IV** **6H – 4C**

Instruction Hours / week: L: 6 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart knowledge on various materials synthesis and processing techniques
- To understand the principles of plastic deformation, creep, fracture, and fatigue
- To introduce thermal analysis techniques for evaluating thermal stability
- To provide a comprehensive understanding of characterization tools, including spectroscopy and microscopy for structural and compositional analysis.
- To explore the applications of advanced materials in energy, environment, and biomedical fields,

Program Outcomes (POs)

PO1: The students will acquire a solid foundation in mathematical, scientific and fundamentals of Physics.
PO2: The students will have a sound knowledge on preparation, processing, Characterization and applications of various kinds of Materials related to physics
PO3: Students will develop an ability to identify, formulate and solve problems related to Physics.
PO4: Students will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
PO5: Students will develop an ability to design and conduct experiments, analyze and interpret data.
PO6: Students will demonstrate knowledge of professional and ethical responsibilities.
PO7: Students will be able to communicate effectively in both verbal and written form.
PO8: Students will show the understanding of impact of Physics on the society and also will be aware of contemporary issues.
PO9: Students will develop confidence for self-education and ability for life-long learning.

Course Outcomes (COs)

Cos	Course Outcomes	Knowledge level
CO1	Describe various materials synthesis and processing techniques such as sol-gel, hydrothermal, electrochemical, and vapor deposition methods.	K2
CO2	Analyze plastic deformation mechanisms, creep, fracture behavior, and fatigue properties of materials under various mechanical conditions.	K4
CO3	Interpret thermal analysis data obtained from TGA, DTA, and DSC to assess material stability and thermal behavior.	K3
CO4	Evaluate structural, morphological, and optical properties of materials using spectroscopy and microscopy techniques	K5
CO5	Apply knowledge of functional materials in designing and understanding their roles in environmental remediation, energy conversion/storage, and biomedical applications.	K3

Articulation Matrix (Use only the relevant POs and PSO)

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	2	2	2	2	3	2
CO2	3	3	3	3	3	2	2	2	2	2	3	2
CO3	3	3	3	3	3	2	2	2	2	2	3	2
CO4	3	3	3	3	3	2	2	2	2	2	3	2
CO5	3	3	3	3	3	2	2	2	2	2	3	2

Unit I – Materials synthesis and processing **(12)**

Sol-gel processing-Hydrothermal/ solvothermal method- Thick and thin film coatings; Thermal and plasma spraying; Dip coating method- Electrochemical Methods- Production of ceramic fibers, Electro-spinning- PVD and CVD techniques- synthesis of polymers- polymerization techniques

Unit II – Plastic deformation and materials testing **(12)**

Plastic Deformation by Slip - Deformation by Twinning - Creep-Mechanism– Effects of Stress- Temperature- Alloying -Creep Resistant Materials –Fracture-Ductile Fracture-Brittle Fracture- Griffiths criterion for Brittle Fracture-Fracture Toughness-The Ductile-Brittle Transition-Methods of Protection against Fracture- Fatigue- The S–N Curve- Factors affecting Fatigue Life.

Unit III – Thermal Analysis **(12)**

Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters.

Unit IV – Spectroscopy and microscopy techniques **(12)**

Photoelectron spectroscopy for elemental and structural analysis: XPS, UPS; Electron Microscopy: SEM, STM, TEM and AFM; Optical Spectroscopy: UV-Vis Absorption, Reflection, Transmission-Photoluminescence (PL) Spectroscopy- FTIR and Raman spectroscopy; Magnetic resonance spectroscopy: ESR, NMR.

Unit V – Materials for Environmental, Energy and biomedical Applications **(12)**

Adsorption studies - kinetics- Photocatalyst- thermocatalyst- Processing and device fabrication in Hydrogen storage, Electrocatalysis-Hydrogen evolution reactions, Oxygen evolution reactions, Oxygen reduction reactions, Supercapacitors, battery materials-Li-ion and Na-ion, Fuel cells, Thermoelectric Materials and Solar Cells- upconversion and downconversion materials- Photodynamic therapy- bioimaging and biosensors

SUGGESTED READINGS

Books for study:

1. Michael F. Ashby and David R. H. Jones, An Introduction to Microstructures, Processing and Design, Third Edition, Elsevier Publisher, (2006)
2. Joel R. Fried, Polymer science and technology, Third edition, Pearson Education, Inc, (2014)
3. William D. Callister, David G. Rethwisch, Materials Science and Engineering,10th Edition, Wiley (2018)
4. V. Raghavan, Materials Science and Engineering, 5th Edition, Prentice Hall of India Pvt.
5. Ltd. (2011).
6. S. Zhang, L. Li, A. Kumar, Materials Characterization Techniques, CRC Press, (2008)
7. A.R. Clarke, C.N. Eberhardt, Microscopy Techniques for Material Science, CRC Press, (2002).
8. Y.Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons.
9. Collin N. Banwell and Elaine M. McCash, Fundamentals of Molecular & Spectroscopy, 4th Edition, McGraw-Hill Publishing Company, (1994)
10. Dharmendra Tripathi et al., Advancements in Nanotechnology for Energy and Environment, Springer, (2022)

Books for reference:

1. J.T. Black and R.A. Kohser, Degarmo‟s Materials and Processes in Manufacturing, 10th
2. ed., Wiley, (2008).
3. Z. Tadmor, C.G. Gogos, Principles of Polymer Processing, 2nd ed., Wiley International, (2006).
4. James F Shakelford, Introduction to Materials Science for Engineers, 8th Edition, Pearson
5. Higher Education, Inc., (2015).
6. Electron Microscopy and Analysis: P. J. Goodhew, J. Humphreys, R. Beanland, 3rd Edition,
7. Taylor & Francis (2001).
8. Transmission Electron Microscopy: A Textbook for Materials Science: David B. Williams,
9. C. Barry Carter, Springer (2008).
10. Xiaoru Wang and Xi Chen, Novel Nanomaterials for Biomedical, Environmental and Energy Applications, Elsevier,(2018).

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https://onlinecourses.nptel.ac.in/noc25_mm52/preview