M.Sc. Physics

(Two Year Programme)

Curriculum, Programme Structure and Course contents

(Prepared in conformity with LOCF & CBCS)

II –year M.Sc. Physics syllabus

(2022-2023 onwards)

DEPARTMENT OF PHYSICS
Manonmaniam Sundaranar University
Tirunelveli

Semester	Course Code	Course	Course Nature	Credits	Contact Hours per Week	continuous Internal Assessment (CIA)	End Semester Exam
I	PPHC11	Classical Mechanics*	Core 1-Theory	4	4	25	75
I	PPHT11		Core 1-Tutorial**	1	1	25	25
I	PPHC12	Mathematical Physics-I	Core 2-Theory	4	4	25	75
I	PPHT12		Core 2-Tutorial	1	1	25	25
I	PPHC13	Quantum Mechanics-I	Core 3-Theory	4	4	25	75
I	PPHT13		Core 3-Tutorial	1	1	25	25
I	PPHC14	Electronics	Core 4-Theory	4	4	25	75
I	PPHL14		Core 4-Practical	1	2	25	25
I	PPHEAX	Elective – I	Elective-Theory	3	3	25	75
I	PPHSAX	Skill Development Course - I	Skill - Practical	1	2	25	25
				24	**29**		
II	PPHC21	Mathematical Physics-II	Core 5-Theory	4	4	25	75
II	PPHT21		Core 5-Tutorial	1	1	25	25
II	PPHC22	Quantum Mechanics-II	Core 6-Theory	4	4	25	75
II	PPHT22		Core 6-Tutorial	1	1	25	25
II	PPHC23	Electromagnetic Theory	Core 7-Theory	4	4	25	75
II	PPHL23		Core 7-Tutorial	1	1	25	25
II	PPHEBX#	Elective – II	Elective-Theory	3	3	25	75
II	PPH	Supportive Course(ONLINE)	Supportive-Theory	3	3	25	75
II	PPHVX	Value-added course – I	Value added-Theory	2^{ψ}	2	25	25
				21	**27**		
III	PPHC31	Thermodynamics and Statistical Mechanics	Core 8-Theory	4	4	25	75
III	PPHT31		Core 8-Tutorial	1	1	25	25
III	PPHC32	Condensed Matter Physics - I	Core 9-Theory	4	4	25	75
III	PPHL32		Core 9-Practical	1	2	25	25
III	PPHC33	Nuclear and Elementary Particle Physics	Core 10-Theory	4	4	25	75
III	PPHL33		Core 10-Practical	1	2	25	25
III	PPHECX	Elective – III	Elective-Theory	3	3	25	75
III	PPH	Supportive Course(ONLINE)	Supportive-Theory	3	3	25	75
III	PPHVX	Value-added course – II	Value added-Theory	2^{ψ}	2	25	25
III	PPHIA	Internship	Skill - Practical	2		25	25
				23	**27**		
IV	PPHC41	Condensed Matter Physics – II*	Core 11-Theory	4	4	25	75
IV	PPHL41		Core 11-Practical	1	2	25	25
IV	PPHC42	Spectroscopy	Core 12-Theory	4	4	25	75
IV	PPHL42		Core 12-Practical	1	2	25	25
IV	PPHEDX	Elective – IV	Elective-Theory	3	3	25	75
IV		Project and Viva-voce	Project - Practical	8	12	50	50
IV	PPHSDX	Skill Development course - II	Skill - Practical	1	2	25	25
				22	**29**		
				90		**925**	**1825**

*e-pg pathshala courses,

**For tutorial class students will be divided into two groups by the respective course teachers

#X in the elective and skill courses shall be substituted by A/B/C depending on the choice of the courses from the respective list of courses.

ψ Value-added courses are certificate courses and the credits earned through them are not included in the 90 credits. These are mandatory extra-credit courses.

THIRD SEMESTER

Core Courses – Theory, Tutorial and Practical courses

Core 8: Thermodynamics and Statistical Mechanics – Theory

Core 8: Thermodynamics and Statistical Mechanics – Tutorial

Core 9: Condensed Matter Physics-I – Theory

Core 9: Condensed Matter Physics-I – Practical

Core 10: Nuclear and Elementary Particle Physics – Theory

Core 10: Nuclear and Elementary Particle Physics – Practical

Group - 3
ELECTIVE COURSES – Theory courses

(a) Materials Processing and Characterisation Technique
(b) X-ray crystallography
(c) Data Analysis and Techniques

Group - 2
VALUE-ADDED COURSES – Theory courses

(a) SEM-microstructure analysis and EDS-composition analysis
(b) Single crystal x-ray diffraction analysis with SHELX
(c) Characterisation of Battery, Supercapcitors and Fuel Cell

Core 8: THERMODYNAMICS AND STATISTICAL MECHANICS (Theory)

L	T	P	C
4	-	-	4

a. Course Code:
PPHC31

b. Course Objectives

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

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

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

d. Course Outline:

UNIT – I: **PHASE TRANSITION**

Thermodynamic potentials - Phase Equilibrium - Gibb's phase rule - Phase transitions and Ehrenfest's classifications –Third law of Thermodynamics. Order parameters – Landau's theory of phase transition - Critical indices - Scale transformations and dimensional analysis.

UNIT – II: **STATISTICAL MECHANICS AND THERMODYNAMICS**

Foundations of statistical mechanics - Specification of states of a system - Micro canonical ensemble - Phase space – Entropy - Connection between statistics and thermodynamics –

Entropy of an ideal gas using the micro canonical ensemble - Entropy of mixing and Gibb's paradox.

UNIT – III: **CANONICAL AND GRAND CANONICAL ENSEMBLES**

Trajectories and density of states - Liouville's theorem - Canonical and grand canonical ensembles - Partition function - Calculation of statistical quantities - Energy and density fluctuations.

UNIT - IV: **CLASSICAL AND QUANTUM STATISTICS**

Density matrix - Statistics of ensembles - Statistics of indistinguishable particles - Maxwell-Boltzmann statistics - Fermi-Dirac statistics – Ideal Fermi gas – Degeneracy - Bose-Einstein statistics - Plank radiation formula - Ideal Bose gas - Bose-Einstein condensation.

UNIT - V : **REAL GAS, ISING MODEL AND FLUCTUATIONS**

Cluster expansion for a classical gas - Virial equation of state – Calculation of the first Virial coefficient in the cluster expansion - Ising model - Mean-field theories of the Ising model in three, two and one dimensions - Exact solutions in one dimension. Correlation of space-time dependent fluctuations - Fluctuations and transport phenomena - Brownian motion - Langevin's theory - Fluctuation-dissipation theorem - The Fokker-Planck equation

BOOKS FOR STUDY:

1. S. K. Sinha, 1990, Statistical *Mechanics*, Tata McGraw Hill, New Delhi.
2. B. K. Agarwal and M. Eisner, 1998, *Statistical Mechanics,* Second Edition New Age International, New Delhi.
3. J. K. Bhattacharjee, 1996, *Statistical Mechanics*: An Introductory Text, Allied Publication, New Delhi.
4. F. Reif, 1965, *Fundamentals of Statistical and Thermal Physics,* McGraw -Hill, New York. M. K. Zemansky, 1968, *Heat and Thermodynamics,* 5th edition, McGraw-Hill New York.

BOOKS FOR REFERENCES:

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

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	H	H	H	L	L	M	H	L
CO2	H	H	H	L	L	M	H	L
CO3	H	H	H	L	L	M	H	M
CO4	H	H	H	L	L	M	H	M
CO5	H	H	H	L	L	M	H	L

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	H	L	L	M	H	L
CO2	H	H	H	L	L	M	H	L
CO3	H	H	H	L	L	M	H	M
CO4	H	H	H	L	L	M	H	M
CO5	H	H	H	L	L	M	H	L

(L – Low, M – Medium, H – High; K_1 – Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5–Evaluate, K_6 – Create)

Core 8: THERMODYNAMICS AND STATISTICAL MECHANICS (Tutorial)

L	T	P	C
-	2	-	1

a. Course Code:
PPHT31

b. Course Objectives

- To solve physical problems using thermodynamic relations, partition function of microcanonical, canonical and grand canonical ensembles and Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distribution functions.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to –

CO1:	Calculate the thermodynamic properties such as Entropy, Enthalpy, Free energies and Specific Heat. (K3)
CO2:	Evaluate the thermodynamical properties of various classical statistical systems by using the different kinds of ensembles and its partition function. (K4)
CO3:	Using certain distribution functions, evaluate the thermodynamical characteristics of various quantum statistical systems. (K5)

d. List of Tutorials:

1. Additive property of Entropy: Assuming that the entropy S and the statistical number Ω of a physical system are related through an arbitrary functional form $S = f(\Omega)$, show that the additive character of S and the multiplicative character of Ω necessarily require that the function be of the form $S = k_B \ln(\Omega)$

2. Classical Ideal Gas:For an ideal classical gas with temperature-independent specific heat, derive the relation between P and V at the adiabatic expansion/compression.

3. Negative Temperature: Consider a system of N non-interacting distinguishable particles each fixed in position and carrying a magnetic moment μ in the presence of the magnetic field H. Each particle may then exist in one of the two energy states $E = 0$ and $E = 2\mu H$. (a) Derive Stirling's approximation for large n (b) Show that this system can have negative absolute temperature.

4. Einstein Model of a Crystalline solid: Derive an expression for the average energy at a temperature τ of a quantum harmonic oscillator having natural frequency ω.

5. Black body radiation: Find expressions for the pressure P, energy density u, entropy density s and specific heat C_v per unit volume of black body radiation in a d-dimensional cavity at temperature T. Evaluate these quantities explicitly for $d = 3$.

6. Adsorption Process: Consider a vapor (dilute monatomic gas) in equilibrium with a submonolayer (i.e., less than oneatomic layer) of atoms adsorbed on a surface. Model the binding of atoms to the surface by a potential energy$V = -\varepsilon_0$.Assume there are N_0possible sites for adsorptionand find the vapor pressure as afunction of surface concentration $\theta = N/N_0$ (N is the number of adsorbed particles).

7. Chemical Potential: Derive a formula for the concentration of electrons in the conduction band of a semiconductor with a fixed chemical potential (Fermi level) μ assuming that in the conduction band $\varepsilon - \mu \gg \tau$.

8. Distribution Functions: Explain Boltzmann statistics, Fermi statistics and Bose statistics in detail and discuss the differences between them. How are they related to the indistinguishability of identical particles?

9. IdealElectron Gas: Consider a non-interacting non-relativistic gas of N spin-$1/2$ fermions at temperature $T = 0$ in a box of area A. (i) Find the Fermi energy. (ii) Show that the total energy is given by $E = \frac{1}{2} n\varepsilon_f$ (iii) Qualitatively discuss the behavior of the heat capacity of this system at low temperatures.

10. Ideal Bose gas:Consider a quantum-mechanical gas of non-interacting spin zero

bosons, each of mass m which are free to move within volume V.(a) Find the energy and heat capacity in the very low temperature region. Discuss why it is appropriate at low temperatures to put the chemical potential equal to zero.(b) Show how the calculation is modified for a photon (mass = 0) gas.

11. Ising Model: Calculate the average energy, entropy, and heat capacity of a three-site ring of Ising-type'spins' ($s_k=\pm1$), with anti-ferromagnetic coupling (of magnitude J) between the sites, in thermal equilibrium at temperature T, with no external magnetic field. Find the asymptotic behavior of its heat capacity for low and high temperatures and give an interpretation of the results.

12. Random Walk: There is an one dimensional lattice with lattice constant a. An atom transits from a site to a nearest neighbor site every τ seconds. The probabilities of transiting to right and left are p and q=1-p respectively. (a) Calculate the average position $\bar{x}$ of the atom at the time $t = N\tau$ where $N \gg 1$ (b) Calculate the mean-square value $\overline{(x - \bar{x})^2}$ at time t.

BOOKS FOR REFERENCE:

1. M. C. Potter, C. W. Somerton, Schaum's Outline of Thermodynamics for Engineers,McGraw Hill, 2019.
2. Yung-Kuo Lim, Problems and Solutionson Thermodynamics andStatistical Mechanics, World Scientific, 2001.
3. D. A. R. Dalvit, J.Frastai and I. D. Lawrie, Problems on statistical mechanics, Institute of Physics Publishing, 1999.
4. S. B. Cahn, G. D. Mahan, B. E. Nadgorny and M. Dresden, A Guide to Physics Problems: Part 2: Thermodynamics, Statistical Physics, and Quantum Mechanics, Springer; 1997th edition, 2007.

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of Cos

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K3)	H	L	L	M	M	H	L	L
CO2 (K4)	H	M	M	H	M	H	L	L
CO3(K5)	H	L	L	L	M	M	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K3)	H	L	L	L	H	H	M	M
CO2 (K4)	H	L	L	L	H	H	L	L
CO3 (K5)	H	L	L	M	H	H	L	L

(L – Low, M – Medium, H – High; K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5–Evaluate, K6-Create)

Core 9: CONDENSED MATTER PHYSICS-I (Theory)

L	T	P	C
4	-	-	4

a. Course Code:
PPHC32

b. 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.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

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

d. Course Outline:

UNIT – I: **CRYSTAL PHYSICS**

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

UNIT – II: **LATTICE DYNAMICS**

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

UNIT – III: **THEORY OF METALS AND SEMICONDUCTORS**

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

UNIT – IV: **MAGNETISM**

Diamagnetism - Quantum theory of paramagnetism - 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 ferrimagnets - Theory of antiferomagnetism - Neel temperature.

UNIT – V: **SUPERCONDUCTIVITY**

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 – Bardeen Cooper Schrieffer (BCS) Theory – BCS to Bose – Einstein Condensation (BEC) regime- Nature of paring and condensation of Fermions. Single particle tunneling - Josephson tunneling - DC and AC Josephson effects - High temperature Superconductors – SQUIDS.

BOOKS FOR STUDY:

1. C. Kittel, 1996, *Introduction to Solid State Physics,* 7th Edition, Wiley, New York.
2. Rita John, Solid State Physics, Tata Mc-Graw Hill Publication.
3. A. J. Dekker, *Solid State Physics*, Macmillan India, New Delhi.
4. M. Ali Omar, 1974, *Elementary Solid State Physics – Principles and Applications,* Addison - Wesley
5. H. P. Myers, 1998, *Introductory Solid State Physics,* 2nd Edition, Viva Book, New Delhi.

BOOKS FOR REFERENCE:

1. J. S. Blakemore, 1974 , *Solid state Physics,* 2nd Edition, W.B. Saunder, Philadelphia
2. H. M. Rosenburg, 1993, *The Solid State,* 3rd Edition, Oxford University Press, Oxford.
3. J. M. Ziman, 1971, Principles *of the Theory of Solids*, Cambridge University Press, London.
4. C. Ross-Innes and E. H. Rhoderick, 1976, *Introduction to Superconductivity,* Pergamon, Oxford.
5. J. P. Srivastava, 2001, *Elements of Solid State Physics,* Prentice-Hall of India, New Delhi.

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	H	M	H	M	M	M	M	M

CO2	H	M	H	M	H	M	H	H
CO3	H	H	H	M	H	M	H	H
CO4	M	M	M	M	M	M	M	M
CO5	M	M	M	M	M	M	M	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	M	H	M	M	M	M	M
CO2	H	M	H	M	H	M	H	H
CO3	H	H	H	M	H	M	H	H
CO4	M	M	M	M	M	M	M	M
CO5	M	M	M	M	M	M	M	M

(L – Low, M – Medium, H – High; K_1 – Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5–Evaluate, K_6-Create)

Core 9: CONDENSED MATTER PHYSICS-I (Practicals)

L	T	P	C
-	-	2	1

a. Course Code:

PPHL31

b. Course Objectives

- To demonstrate what was taught in the theory paper such as indexing XRD patterns, plotting Brillouin zone, Hall effect and thermal conductivity and M-H loop

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure	K1
CO2:	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.	**K1, K2**
CO3:	Student will be able to comprehend the heat conduction in solids	**K3**

d. List of Experiments (Any 7 experiments)

1. Indexing the XRD patterns of cubic metallic systems of sc, bcc and fcc
2. Calculation of structure factor for NaCl
3. Plotting the first Brillouin zone for Si
4. Measurement of thermal conductivity of solids
5. Measurement of Hall voltage and mobility of Ge crystal
6. Calculate and visualization of Fermi surface
7. Measurement of Bandgap of the given crystal using four probe method

8. Measurement of specific heat of solids
9. Measurement of M-H curves to get coercivity, saturation and remnant magnetization of soft and hard magnetic materials
10. Measurement of magnetic moment per formula unit of soft and hard magnetic materials
11. Measurement of magnetic susceptibility of solids using Guoy balance method
12. Measurement of magnetic susceptibility of liquids using Quinke's method
13. Any other experiments

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of Cos

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K3)	H	L	L	M	M	H	L	L
CO2 (K4)	H	M	M	H	M	H	L	L
CO3(K5)	H	L	L	L	M	M	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K3)	H	L	L	L	H	H	M	M
CO2 (K4)	H	L	L	L	H	H	L	L
CO3 (K5)	H	L	L	M	H	H	L	L

(L – Low, M – Medium, H – High; K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5–Evaluate, K6-Create)

Core 10: NUCLEAR AND ELEMENTARY PARTICLE PHYSICS (Theory)

L	T	P	C
4	-	-	4

a. Course Code:
PPHC33

b. Course Objectives

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

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Gain knowledge about the concepts of helicity, parity, angular correlation and internal conversion.	K1, K5
CO2:	Demonstrate knowledge of fundamental aspects of the structure of the	K2,

	nucleus, radioactive decay, nuclear reactions and the interaction of radiation and matter.	K3
CO3:	Use the different nuclear models to explain different nuclear phenomena and the concept of resonances through Briet-Weigner single level formula	K3
CO4:	Analyze data from nuclear scattering experiments to identify different properties of the nuclear force.	K3, K4
CO5:	Summarize and identify allowed and forbidden nuclear reactions based on conservation laws of the elementary particles.	K5

d. Course Outline:

UNIT – I: **NUCLEAR MODELS**

Liquid drop model – Weizacker mass formula – Isobaric mass parabola –Mirror Pair - Bohr Wheeler theory of fission – shell model – spin-orbit coupling – magic numbers – angular momenta and parity of ground states – magnetic moment – Schmidt model – electric Quadrapole moment - Bohr and Mottelson collective model – rotational and vibrational bands.

UNIT – II: **NUCLEAR FORCES**

Nucleon – nucleon interaction – Tensor forces – properties of nuclear forces – ground state of deuteron – Exchange Forces - Meson theory of nuclear forces – Yukawa potential – nucleon-nucleon scattering – effective range theory – spin dependence of nuclear forces - charge independence and charge symmetry – isospin formalism.

UNIT – III: **NUCLEAR REACTIONS**

Kinds of nuclear reactions – Reaction kinematics – Q-value – Partial wave analysis of scattering and reaction cross section – scattering length – Compound nuclear reactions – Reciprocity theorem – Resonances – Breit Wigner one level formula – Direct reactions - Nuclear Chain reaction – four factor formula.

UNIT – IV: **NUCLEAR DECAY**

Beta decay – Continuous Beta spectrum – Fermi theory of beta decay - Comparative Half-life –Fermi Kurie Plot – mass of neutrino – allowed and forbidden decay — neutrino physics – Helicity - Parity violation - Gamma decay – multipole radiations – Angular Correlation - internal conversion – nuclear isomerism – angular momentum and parity selection rules.

UNIT – V: **ELEMENTARY PARTICLES**

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

BOOKS FOR STUDY:

1. D. C. Tayal – Nuclear Physics – Himalaya Publishing House (2011)
2. K. S. Krane – Introductory Nuclear Physics – John Wiley & Sons (2008)
3. R. Roy and P. Nigam – Nuclear Physics – New Age Publishers (1996)
4. S. B. Patel – Nuclear Physics – An introduction – New Age International Pvt Ltd Publishers (2011)

5. S. Glasstone – Source Book of Atomic Energy – Van Nostrand Reinhold Inc.,U.S.- 3rd Revised edition (1968)

BOOKS FOR REFERENCE:

1. L. J. Tassie – The Physics of elementary particles – Prentice Hall Press (1973)
2. H. A. Enge – Introduction to Nuclear Physics – Addison Wesley, Publishing Company. Inc. Reading. New York, (1974).
3. Kaplan – Nuclear Physics – 1989 – 2nd Ed. – Narosa (2002)
4. Bernard L Cohen – Concepts of Nuclear Physics – McGraw Hill Education (India) Private Limited; 1 edition (2001)
5. B.L. Cohen, 1971, Concepts of Nuclear Physics, TMCH, New Delhi.

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	H	H	M	M	M	M	M	M
CO2	H	H	M	M	L	M	L	M
CO3	H	H	L	M	L	M	L	L
CO4	H	H	M	H	M	H	M	M
CO5	H	H	M	H	M	H	M	H

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	M	M	M	M	M	M
CO2	H	H	M	M	L	M	L	M
CO3	H	H	L	M	L	M	L	L
CO4	H	H	M	H	M	H	M	M
CO5	H	H	M	H	M	H	M	H

(L – Low, M – Medium, H – High; K_1 – Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5–Evaluate, K_6-Create)

Core 10: NUCLEAR AND ELEMENTARY PARTICLE PHYSICS (Practical)

L	T	P	C
-	-	2	1

d. Course Code:
PPHL33

e. Course Objectives

- To demonstrate what was taught in the theory paper such as G.M. counter, inverse square of gamma source

f. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure	K1
CO2:	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.	**K1, K2**
CO3:	Student will be able to comprehend the heat conduction in solids	**K3**

d. List of Experiments (Any 7 experiments)

1. Determine the characteristics of the G.M. tube
2. Find the operating voltage of the G.M. tube and also determine the mass coefficient of the given Al absorption
3. Find the inverse square law of the given gamma source and its dead time of the G.M. tube.
4. Nuclear reaction – Balancing and compound nucleus formation
5. Decay of alpha, beta and gamma rays
6. Q-value calculation in nuclear reactions
7. Dating of archeological excavation remains
8. Measurement of mean life times of elementary particles decay
9. Any other experiment

f. Mapping of COs to POs & PSOs with correlation level and Cognitive level of Cos

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K3)	H	L	L	M	M	H	L	L
CO2 (K4)	H	M	M	H	M	H	L	L
CO3(K5)	H	L	L	L	M	M	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K3)	H	L	L	L	H	H	M	M
CO2 (K4)	H	L	L	L	H	H	L	L
CO3 (K5)	H	L	L	M	H	H	L	L

(L – Low, M – Medium, H – High; K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5–Evaluate, K6-Create)

Group - 3
ELECTIVE COURSES – Theory courses – Third semester

(a) Materials Processing and Characterisation Technique
(b) X-ray crystallography
(c) Data Analysis and Techniques

a. MATERIALS PROCESSING AND CHARACTERISATION TECHNIQUES

L	T	P	C
3	-	-	3

OBJECTIVES:

- To impart knowledge on various materials growth, synthesis and processing techniques
- To learn the structural, morphology, and surface characterization techniques.

UNIT-I: CRYSTAL GROWTH
Significance of crystal growth - Naturally occurring crystal growth processes - Crystal growth processes in laboratory and industrial scale - Classification of crystal growth methods – Growth from solutions -Nucleation: Homogeneous and heterogeneous, Solubility phase diagram- Saturation-Supersaturation- Metastable zone width-Slow evaporation and slow cooling methods, Growth from gel-Growth from flux-Growth from melt- Bridgeman-Stockbarger method-Czochralski pulling method- Growth from vapour - Sublimation method.

UNIT-II:VACUUMTECHNIQUES
Units and range of vacuua – Formulas for important quantities – Qualitative description of pumping process – Surface processes and outgassing – Gas flow mechanism – Classification of pumps :Positive displacement pumps – Kinetic pumps – Entrapment pumps - Classification of pressuregauges : Total pressure gauges –Hydrostatic pressure gauges - Thermal conductivity gauges –Ionization gagues – Vacuum system : simple rotary, diffusion, turbo molecular, ultra- high vacuumand cryo-pumpedsystems.

UNIT-III: FABRICATION OF THIN FILMS AND PREPARATION OF NANOMATERIALS
Plasma arc discharge-sputtering-chemical vapour deposition-pulsed laser deposition-molecular beam epitaxy-Electrochemical deposition- SILAR method; Solid-State Reaction - Sol-Gel Technique - Hydrothermal growth - Ball Milling – Combustion synthesis –

Sonochemical method - Microwave synthesis – Co-precipitation.

UNIT-IV: CHARACTERIZATION TOOLS-I

Working principles, measurement and data analysis; powder x-ray diffraction and single crystal x-ray diffraction. Working principles, measurement and data analysis; Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC)

UNIT-IV: CHARACTERIZATION TOOLS-II

Working principles, measurement and data analysis; SEM and EDS
Working principles, measurement and data analysis; AFM

BOOKS FOR REFERENCE:

1. Maissel and Glange, Handbook of Thin Film Technology, McGraw Hill, First Edition, 1970.
2. A. Roth, Vacuum Technology, North Holland, Third Edition, 1990
3. Pipko A, Pliskosky V, Fundamentals of VacuumTechniques, MIR Publishers, First Edition, 1984
4. K. L. Chopra, Thin Films Phenomena, McGraw Hill,First Edition, 1969
5. D. K. Avasthi, A. Tripathi, A.C. Gupta, Ultra High VacuumTechnology, Allied Publishers, Private Limited, 2002
6. Kasturi Lal Chopra, SuhitRanjan Das, Thin Film Solar Cells, Plenum Press,New York, 1983
7. A.Chambers, R.K.Fitch and B.S.Halliday, Basic Vacuum Technology, IOP Publishing Ltd ,2ND Edition ,1998
8. A.Roth, Vacuum Technology, Elsevier Science, 3rd Edition, 1990
9. Edited by C. Suryanarayana, Non-equilibrium processing of materials (Chapter – 6) Pergamon, 1999
10. P.V. Ananthapadmanabhan and N. Venkataramani, Thermal plasma processing Pergamon materials series Vol 2, 1999
11. J. Reece Roth, Industrial plasma engineering - Applications to Nonthermal plasma processing (Vol. 2)Institute of Physics Publishing, Bristol, 2001
12. Maher I. Boulos, Pierre Fauchais and Emil Pfender, Thermal plasmas– Fundamentals and Applications (Vol. 1), Springer Science, NY, 1994
13. Edited by Rainer Hippler, Sigismund Pfau, Martin Schmidt, Karl H. Schoenbach, Low temperature plasma physics, Wiley-Vch, Berlin, 2001

b. X-RAY CRYSTALLOGRAPHY

L	T	P	C
3	-	-	3

OBJECTIVES:

- To study the production of X-rays, crystals and its symmetry and their properties.
- To understand the X-ray intensity data collection techniques, data reduction and structure solution and refinement from crystallographic method.

UNIT - I: BRAVAIS LATTICES AND SYMMETRY ELEMENTS IN 3 DIMENSIONS

Development of 3D lattices – Choice axes and unit cells - seven primitive lattices – lattice centering – nonprimitive lattices – number of lattice points per unit cell – fractional coordinates – unit cell calculations – interplanar spacing. Symmetry Elements – macroscopic symmetry elements - Combinations of macroscopic symmetric operations – rotation at a point – axial combinations – rotations and reflection – rotation and inversion – proper and improper rotations – reflection and inversion – classification of symmetry operations

UNIT – II: DERIVATION OF POINT GROUPS
Conventional method of derivation of point groups – Point group notations – Linear orthogonal transformation – symmetry operations and group theory – matrix representation of symmetry operations - matrix method derivation of point group – equivalent positions in point groups – Laue symmetry – point groups, crystal classes and crystal systems

UNIT – III: DERIVATION OF SPACE GROUPS
Macroscopic symmetry elements – combination of symmetry operations – general equivalent positions and special positions – systematic absences – space groups – classification – derivation of space groups - Crystal planes and zones – crystal directions and zone axes – Miller-Bravais indices – transformation of indices – crystal projections –reciprocal lattices

UNIT – IV: DIFFRACTION METHODS, X-RAY INTENSITY, STRUCTURE FACTOR
X-ray diffraction – Bragg's law – Laue equations – diffraction condition – Diffraction experiments - powder method, indexing powder lines – Laue method and indexing Precession method – x-ray diffractometers – Neutron and Electron diffraction - Structure factor – Lorentz factor – polarization factor – temperature factor – multiplicity factor – absorption factor – extinction – R-factor

UNIT – V: CRYSTAL STRUCTURE ANALYSIS AND REFINEMENT
Trial and error method – Patterson function – heavy atom method – isomorphous replacement – superposition method – direct methods – Successive and difference Fourier synthesis – least squares refinement – constrained least squares refinement method – automation of structural analysis

BOOKS FOR REFERENCE:
1. Essentials of Crystallography – M.A. Wahab, Narosa Publishing House, New Delhi, Second Edition 2014
2. X-ray Structure Determination – G.H. Stout and L.H.Jensen, John Wiley Publications, Second Edition, 1989.
3. Fundamentals of Crystallography - C. Giacovazzo, Oxford Press, Second Edition, 2011.
4. Structure Determination by X-ray Crystallography - Ladd and Palmer, Plenum Publishing Corporation, Second Edition, 2013.
5. X-ray Crystallography- Woolfson, Cambridge University Press Publications. Second Edition, 1997.
6. Elements of X-ray Crystallography - Leonid V. Azaroff, McGraw Hill Publications, 1968.
7. Crystal Structure analysis for Chemist and Biologist – J.P. Glusker, M. Lewis and M. Rossi, VCH Publishers Inc, 1994.
8. Crystal, X-ray and Proteins – D. Sherwood, and J. Cooper, Oxford University Press, 2010.
9. An Introduction to Crystallography – F.C. Phillips, John Wiley Publications, 1971.
10. International tables for Crystallography.

c. DATA ANALYSIS AND TECHNIQUES

OBJECTIVES:

L	T	P	C
3	-	-	3

- To learn the importance of error analysis, and various methods to analyse error

- To effectively learn statistical tools needed for data analysis.
- To understand the behaviour of distribution of data

UNIT-I: ERRORS AND ITS IMPORTANCE

Approximate numbers and Significant Figures – Rounding of Numbers – Absolute, Relative and Percentage errors – Relation between Relative error and the significant figures – The general formula for errors – Formulas to the fundamental operations of arithmetic and logarithms – Accuracy in the evaluation of a Formula – Accuracy in the Determination of arguments from a tabulated function – Accuracy of Series approximations – Errors in Determinants.

UNIT-II: ERRORS AND CURVE FITTING

Errors of Observations and Measurement – The law of accidental errors – The probability of errors lying between given limits – The probability equation – The law of error of a linear function of independent quantities – The probability integral and its evaluations – The probability of hitting a target – The principle of least squares – Weighted observations – Residuals – The most probable value of a set of direct measurements – Law of error for residuals – Agreement between theory and experience.

UNIT-III: PROBABILITY BASICS

Chance Experiments and Events – Definition of Probability – Basic Properties: Addition and multiplication laws of Probability – Conditional Probability, population, variants, collection, tabulation and graphical representation of data– Some General Probability Rules – Estimating Probabilities Empirically using Simulation -frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis.

UNIT-IV: PROBABILITY DISTRIBUTIONS

Random variables – Probability distribution of discrete random variables – Probability distribution for continuous random variables – Mean and Standard deviation of a random variable - Binomial and geometric distribution – Normal distributions - Poisson distribution - Gaussian distribution, exponential distribution – additive property of normal variants, confidence limits, Bi-varite distribution, Correlation and Regression, Chi-Square distribution.

UNIT-V: ERRORS IN MEASUREMENTS

Measurement, Direct and Indirect – Precision and Accuracy – Measures of Precision – Relations between the Precision measures – Geometric significance of μ, r and η – Relation between probable error, and the probable errors of the arithmetic and weighted means – Computation of the precision measures from the residuals – The combinations of sets of measurements when the P.E.'s of Sets are given – The probable error of any function of independent quantities whose P.E.'s are known – The two fundamental problems of indirect measurements – Rejection of observations and measurement.

BOOKS FOR REFERENCE:

1. Introduction to Statistics and Data Analysis, R. Peck, C. Olsen and J.L. Devore, Cengage Learning, 5th Edition, 2014
2. Donald L. Smith: Probability statistics and data uncertainties in nuclear science and technology, American nuclear society, 1991
3. Numerical Mathematical Analysis, J. B. Scarborough, Oxford and IBH Publishing Company, 6th

Edition, 1990

4. Semyen G. Rabinovich: Measurement errors and Uncertainties –theory and practice,Springer,2005

Group - 2
VALUE-ADDED COURSES – Theory course – Third Semester

(a) SEM-microstructure analysis and EDS-composition analysis
(b) Single crystal x-ray diffraction analysis with SHELX
(c) Characterisation of Battery, Supercapcitors and Fuel Cell

(a) SEM-MICROSTRUCTURE ANALYSIS AND EDS-COMPOSITION ANALYSIS

L	T	P	C
2	-	-	2

a. **Course Code:**
PPHVBA

b. **Course objectives:**
- To learn working principle of various components of SEM and EDS and their maximum operation conditions to record quality SEM micrograph
- To provide the hands-on experience of estimation of the average grain/particle size and its distribution and elemental quantification of the material

c. **Course Outcome**

On the successful completion of the value added course, the learner will be able to

CO1: Explain the working principle of SEM and EDS (K2)

CO2: Measure the micrographs and EDS spectra (K3)

CO3: Deduce the average grain/particle size, its distribution and elemental quantification. (K5)

d. **Course outline** **(contact hours: 30)**

Module 1: Limitations of the human eye, optical microscope (2 hours)

Module 2: Functions of SEM components and SEM imaging modes (3 hours)

Module 3: Filaments; Tungsten, LaB_6 and FE guns – electron lenses; focusing, magnification, aperture, aberrations – probe diameter and probe current (45 lectures)

Module 4: Performance of SEM modes; resolution mode, high current mode, depth of focus, low voltage and HR (4 hours)

Module 5: E-beam interaction with specimen – influence of beam and specimen on interaction volume - backscattered electrons – secondary electrons (4 hours)

Module 6: Imaging process and detectors (3 hours)

Module 7: Continuous and characteristic x-ray production – depth of x-ray production (4 hours)

Module 8: Energy dispersive x-ray spectra, mapping and quantitative composition analysis (4 hours)

Module 9: Average grain/particle size estimation using ImageJ software (2 hours)

BOOK FOR REFERENCE:

1. Joseph Goldstein, Dale Newbury, David loy, Charles Lyman, Patrick Echlin, Eric Lifshin, Linda Sawyer and Joseph Michael , Scanning Electron Microscopy and x-ray microanalysis, Third Edition, Springer Science, New York (2003)
2. Ray F. Egerton, Physical Principles of Electron Microscopy, Springer Science (2005)Rietveld
3. ImageJ software www.imagej.net

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1(K2)	L	M	L	H	L	M	M	L
CO2(K3)	L	H	M	L	L	M	M	M
CO3(K5)	L	M	H	L	L	L	M	M

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1(K2)	L	L	M	L	H	M	M	L
CO2(K3)	L	H	H	L	L	M	H	M
CO3(K5)	L	L	H	L	L	L	H	H

(b) SINGLE CRYSTAL X-RAY DIFFRACTION ANALYSIS WITH SHELX

L	T	P	C
2	-	-	2

a. Course Code:
PPHVBB

b. Course objective:
- To teach space groups and working of single crystal x-ray diffraction and structure determination of crystals and small molecules

c. Course outcome
On the successful completion of NMR spectral analysis (value added certificate course), the learner will be able to

CO1 Explain the symmetry elements, deduction of space group of materials and single x-ray diffraction (K2)

CO2 Structure elucidation from single crystal diffraction data using SHELXTL (K4)

CO3 Determine the structure of small molecules using APEX (K5)

d. Course outline (contact hours: 30)

Module 1: Symmetry Elements – macroscopic symmetry elements - Combinations of macroscopic symmetric operations – rotation at a point – axial combinations – rotations and reflection – rotation and inversion – proper and improper rotations – reflection and inversion – classification of symmetry operations (6 hours)

Module 2: Derivation of Space Groups: Macroscopic symmetry elements – combination of symmetry operations – general equivalent positions and special positions – systematic absences – space groups – classification – derivation of space groups (6 hours)

Module 3: Single crystal x-ray diffraction fundamental, instrumentation and experimental procedure (4 hours)

Module 4: A guide to using SHEXTL structural analysis (5 hours)

Module 5: APEX software – a guide to using it (4 hours)

Module 6: SHELX - a guide to structure elucidation of small molecules (5 hours)

BOOK FOR REFERENCE:

1. M.A. Wahab, Essentials of Crystallography, Narosa Publishing House, New Delhi, Second Edition 2014
2. George M. Sheldrick, A short history of SHELX, Acta Cryst. (2008). A64, 112–122
3. George M. Sheldrick, Crystal structure refinement with SHELXL, Acta Cryst. (2008). A64, 112–122.
4. https://xray.uky.edu/Resources/manuals/Shelxtl-manual.pdf
5. https://www.bruker.com/en/products-and-solutions/diffractometers-and-x-ray-microscopes/single-crystal-x-ray-diffractometers/sc-xrd-software/apex.html
6. https://shelx.uni-goettingen.de/

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K2)	L	M	L	H	L	M	M	L
CO2 (K4)	L	H	M	L	L	M	M	M

CO3 (K5)	L	M	H	L	L	L	M	M

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K2)	L	L	M	L	H	M	M	L
CO2 (K4)	L	H	H	L	L	M	H	M
CO3 (K5)	L	L	H	L	L	L	H	H

(c) CHARACTERISATION OF BATTERY, SUPERCAPACITORS AND FUEL CELL

L	T	P	C
2	-	-	2

a. **Course Code:**
PPHVBC

b. **Course objectives:**

- To teach the basic of electrochemistry with 2 and 3 electrodes and impedance spectroscopy and analysis of the data obtained from measurement.

c. **Course Outcome**

On the successful completion of the value added course, the learner will be able to

CO1: Explain the basic principles of electrochemistry for energy storages aspects (K2)

CO2: Measure the CV and impedance spectra for suitable electrochemical conditions (K3)

CO3: Determine the performance parameters from CV and EIS measurements (K5)

d. **Course outline (contact hours: 30)**

Module 1: Electrochemical cells and reactions, cell potential, reference and counter electrode, potential as electron energy, current as reaction rate, control of current-potential curves – mass-transfer reactions (4 hours)

Module 2: Faradaic and non-Faradaic process, factors affecting rates, electrochemical cell types, two, three electrode cells, electrode/solution interface (6 hours)

Module 3: Basic electrochemical thermodynamics, reversibility, free energy and cell emf, emf and concentration, formal potential reference electrodes (6 hours)

Module 4: Basic kinetics of electrode reactions, dynamic equilibrium, Arrhenius equation and potential energy surface, essentials of electrode reactions, Butler-Volmer model (5 Lectures)

Module 5: Electrochemical Impedance spectroscopy, cell impedance, review ac circuits, equivalent circuits, measurement of resistance and capacitance (5 hours)

Module 6: AC voltametry, reversible systems, quasireversible and irreversible systems, cyclic ac voltametry (4 lectures)

BOOK FOR REFERENCE:

1. Allen J. Bard, Larry R. Faulkner, Henry S. White, Electrochemical Methods Fundamentals and Applications, Third Edition, John Wiley & Sons Ltd (2022)

e. **Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs**

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1(K2)	L	M	L	H	L	M	M	L

CO2(K3)	L	H	M	L	L	M	M	M
CO3(K5)	L	M	H	L	L	L	M	M

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1(K2)	L	L	M	L	H	M	M	L
CO2(K3)	L	H	H	L	L	M	H	M
CO3(K5)	L	L	H	L	L	L	H	H

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FOURTH SEMESTER

Core Courses –Theory and Practical courses

Core 11: Condensed Matter Physics-II – Theory

Core 11: Condensed Matter Physics-II – Practical

Core 12: Spectroscopy – Theory

Core 12: Spectroscopy – Practical

Group - 4
ELECTIVE COURSES – Theory courses

(a) Thin Films
(b) Materials Science
(c) Medical Physics

Group - 2
SKILL COURSES – Practical courses

(a) PicMicrocontroller – Applications
(b) NI LabVIEW - Applications

Core 11: CONDENSED MATTER PHYSICS-II (Theory)

L	T	P	C
4	-	-	4

a. Course Code:

PPHC41

b. 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.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

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

d. Course Outline:

UNIT – I: **CRYSTAL IMPERFECTIONS**

Module 1: Point Imperfections; Vacancy concentrations in monoatomic solid – Frenkel and Schottky imperfections (4 hours)

Module 2: Line Imperfections; Edge and Screw dislocation – Burger’s vector and circuit - presence of dislocation – slip planes and directions (4 hours)

Module 3: Surface imperfections; Grain boundary – tilt and twist boundary – stacking faults of fcc and hcp crystals (4 hours)

UNIT – II: **BAND THEORY**
Module 4: Construction of Brillouin zone in one, two and three dimensions (3 hours)

Module 5: Symmetry properties of the energy function, extended, reduced and periodic zone scheme – effective mass of electron (3 hours)

Module 6: Nearly free electron model – tight binding approximation – orthogonalised plan wave method – pseudopotential method – conductors, semiconductor and insulator (6 hours)

Module 7: Fermi surface and Brillouin zones – constructing Fermi surfaces – Fermi surface in SC, BCC and FCC metals (4 hours)

UNIT – III: **DIELECTRIC PROPERTIES OF MATERIALS**
Module 8: Dipole moment – Polarisation – Electric field of a dipole – local electric field at an atom (3 hours)

Module 9: Complex dielectric constant and loss - Dielectric constant and its measurement – electronic and ionic polarisability – classical theory of electronic and dipolar polarisability - temperature dependence of polarisability (5 hours)

Module 10: classification piezo-pyro and ferroelectric crystals – ferroelectricity – ferroelectric domain – piezoelectrics – pyroelectric (3 hours)

UNIT – IV: **OPTICAL PROPERTIES OF SOLIDS**
Module 11: Classical Drude model – ionic conduction – refractive index- dielectric constant (4 hours)

Module 12: optical absorption in metals, insulators and semiconductors (2 hours)

Module 13: Colour centers – excitons – luminescence (3 hours)

Module 14: Maser and laser, application of laser and optical fibers (3 hours)

UNIT – V: **ANISOTROPIC PROPERTIES OF MATERIALS**
Module 15: Classification and description of physical properties (3 hours)

Module 16: Symmetry of physical property - Transformation law of second rank tensor (3 hours)

Module 17: Effect of crystal symmetry on physical properties (3 hours)

Module 18: Physical properties second, third and fourth rank tensors (3 hours)

BOOKS FOR STUDY:

1. C. Kittel, 1996, *Introduction to Solid State Physics,* 7th Edition, Wiley, New York.
2. Rita John, Solid State Physics, Tata Mc-Graw Hill Publication.
3. A. J. Dekker, *Solid State Physics*, Macmillan India, New Delhi.
4. M. Ali Omar, 1974, *Elementary Solid State Physics – Principles and Applications,* Addison - Wesley
5. H. P. Myers, 1998, *Introductory Solid State Physics,* 2nd Edition, Viva Book, New Delhi.

BOOKS FOR REFERENCE:

1. J. S. Blakemore, 1974 , *Solid state Physics,* 2nd Edition, W.B. Saunder, Philadelphia
2. H. M. Rosenburg, 1993, *The Solid State,* 3rd Edition, Oxford University Press, Oxford.
3. J. M. Ziman, 1971, Principles *of the Theory of Solids*, Cambridge University Press, London.
4. C. Ross-Innes and E. H. Rhoderick, 1976, *Introduction to Superconductivity,* Pergamon, Oxford.
5. J. P. Srivastava, 2001, *Elements of Solid State Physics,* Prentice-Hall of India, New Delhi.

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K1)	H	L	L	M	M	H	L	L
CO2 (K2)	H	M	L	M	M	H	L	L
CO3 (K3)	H	M	L	M	H	H	L	H
CO4 (K4)	H	M	L	M	H	H	L	H
CO5 (K5)	H	L	L	L	H	L	L	H
CO6 (K6)	H	L	L	L	L	L	L	L

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K1)	H	L	L	L	H	H	L	L
CO2 (K2)	H	L	L	L	H	H	L	L
CO3 (K3)	H	L	L	L	H	H	M	M
CO4 (K4)	H	L	L	L	H	H	M	L
CO5 (K5)	H	L	L	L	H	H	L	L
CO6 (K6)	H	L	L	L	H	H	L	L

(L – Low, M – Medium, H – High; K_1 – Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5–Evaluate, K_6-Create)

Core 11: CONDENSED MATTER PHYSICS-II (Practicals)

L	T	P	C
-	2	-	1

a. Course Code:

PPHL41

b. 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.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Student will be able to list out the crystal systems, symmetries allowed in a system and also the diffraction techniques to find the crystal structure	**K1**
CO2:	Students will be able to visualize the idea of reciprocal spaces, Brillouin Zone and their extension to band theory of solids.	**K1, K2**
CO3:	Student will be able to comprehend the heat conduction in solids	**K3**

d. List of Experiments (Any 7 experiments)

1. Average grain size & its distribution analysis using linear intercept method for a given micrographs
2. Average particle size & its distribution analysis using linear intercept method for a given micrographs
3. Measurement of temperature dielectric constant of solids and determination of Curie temperature
4. Construction the Fermi surface of metals with SC, BCC and FCC
5. Measurement of Polarisation-Electric field loop of a ferroelectric materials and analysis of loop parameters
6. Tauc's plot analysis to determine the bandgap, nature of the bandgap and its absorption coefficient of semiconductor thin films
7. Measurement of temperature dependent ionic conductivity of the insulators and determination of activation energy.
8. Any other experiments

e.Mapping of COs to POs & PSOs with correlation level and Cognitive level of Cos

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K3)	H	L	L	M	M	H	L	L
CO2 (K4)	H	M	M	H	M	H	L	L
CO3(K5)	H	L	L	L	M	M	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K3)	H	L	L	L	H	H	M	M
CO2 (K4)	H	L	L	L	H	H	L	L
CO3 (K5)	H	L	L	M	H	H	L	L

(L – Low, M – Medium, H – High; K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5–Evaluate, K6-Create)

Core 12: SPECTROSCOPY (Theory)

L	T	P	C
4	-	-	4

a. Course Code:
PPHC42

b. 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.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Understand fundamentals of rotational spectroscopy, view molecules as elastic rotors and interpret their behaviour. Able to quantify their nature and correlate them with their characteristic properties.	**K2**
CO2:	Understand the working principles of spectroscopic instruments and theoretical background of IR spectroscopy. Able to correlate mathematical process of Fourier transformations with instrumentation. Able to interpret vibrational spectrum of small molecules.	**K2, K3**
CO3:	Interpret structures and composition of molecules and use their knowledge of Raman Spectroscopy as an important analytical tool	**K5**
CO4:	Use these resonance spectroscopic techniques for quantitative and qualitative estimation of a substances	**K4**
CO5:	Learn the electronic transitions caused by absorption of radiation in the UV/Vis region of the electromagnetic spectrum and be able to analyze a simple UV spectrum.	**K1, K5**

d. Course Outline:

UNIT-I: **ELECTRONIC SPECTROSCOPY OF ATOMS AND MOLECULES**

Module l: Structure of atoms, shape of atomic orbitals, atomic quantum numbers, Hydrogen atom spectrum (3 hours)

Module 2: Orbital, spin and total angular momentum, fine structure of Hydrogen atom (3 hours)

Module 3: Building up principle, angular momentum of many electron atoms, coupling schemes, term symbols, spectra of Helium and alkaline earths atoms (3 hours)

Module 4: Electronic structure of diatomic molecules, molecular orbital theory, shape, electronic angular momentum of diatomic molecules, electronic spectra of polyatomic molecules and chemical analysis application (5 hours)

UNIT-II: **MICROWAVE SPECTROSCOPY**

Module 5 Rotational spectra of diatomic molecules - Rigid Rotor (Diatomic Molecules) - reduced mass – rotational constant - Effect of isotopic substitution (4 hours)

Module 6 Non rigid rotator – centrifugal distortion constant- Intensity of Spectral Lines (2 hours)

Module 7 Polyatomic molecules – linear – symmetric asymmetric top molecules (3 hours)

UNIT-III: **INFRARED SPECTROSCOPY**

Module 8 Vibrations of simple harmonic oscillator – zero-point energy- Anharmonic oscillator – fundamentals, overtones and combinations frequencies (3 hours)

Module 9 Diatomic Vibrating Rotator- PR branch – PQR branch- vibration-rotation spectrum of CO (2 hours)

Module 10 Vibrations of polyatomic molecules - Fundamental modes of vibration of H_2O and CO_2 – analysis of vibrational spectra by IR techniques (3 hours)

Module 11 Outline of spectrometer - Double and single beam operation – Fourier Transform Infrared Spectroscopy (2 hours)

UNIT-IV: **RAMAN SPECTROSCOPY**

Module 12 Theory of Raman Scattering - Classical theory – Stokes and anti-stokes line - molecular polarizability – polarizability ellipsoid - Quantum theory of Raman effect (3 hours)

Module 13 Rotational Raman spectra of linear molecule - symmetric top molecules (2 hours)

Module 14 Raman activity of H_2O and CO_2 - Mutual exclusion principle – vibrational Raman spectra of $CHCl_3$, degree of depolarization – polarized Raman spectra of CH_4 (3 hours)

Module 15 Structure determination from Raman and IR spectra of polyatomic molecules – Dispersive and FT Raman spectroscopy- SERS (3 hours)

UNIT-V: **NUCLEAR MAGNETIC AND ELECTRON SPIN RESONANCE**

SPECTROSCOPY

Module 16 Nuclear and Electron spin-Interaction with magnetic field - Population of Energy levels - Larmor precession- Relaxation times - Double resonance- Chemical shift and its measurement (3 hours)

Module 17 NMR of Hydrogen nuclei - Indirect Spin -Spin Interaction – interpretation of simple organic molecules - Instrumentation techniques of NMR spectroscopy – NMR in Chemical industries- MRI Scan (3 hours)

Module 18 Electron Spin Resonance - Basic principle –Total Hamiltonian (Direct Dipole-Dipole interaction and Fermi Contact Interaction) – Hyperfine Structure (Hydrogen atom) (3 hours)

Module 19 ESR Spectra of Free radicals –g-factors – Instrumentation - Medical applications of ESR (3 hours)

. TEXT BOOKS

1. C N Banwell and E M McCash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw–Hill, New Delhi.
2. Raj Kumar, Atomic and Molecular Spectra: Laser
3. G Aruldhas, 1994, Molecular Structure and Molecular Spectroscopy, Prentice–Hall of India, New Delhi.
4. D.N. Satyanarayana, 2001, *Vibrational Spectroscopy and Applications*, New Age International Publication.
5. B.K. Sharma, 2015, *Spectroscopy*, Goel Publishing House Meerut.
6. Kalsi.P.S, 2016, Spectroscopy of Organic Compounds (7^{th} Edition), New Age International Publishers.

REFERENCE BOOKS

1. J L McHale, 2008, Molecular Spectroscopy, Pearson Education India, New Delhi.
2. J M Hollas, 2002, Basic Atomic and Molecular Spectroscopy, Royal Society of Chemistry, RSC, Cambridge.
3. B. P. Straughan and S. Walker, 1976, Spectroscopy Vol. I, Chapman and Hall, New York.
4. K. Chandra, 1989, Introductory Quantum Chemistry, Tata McGraw Hill, New Delhi.
5. Demtroder. W, Laser Spectroscopy: Basic concepts and Instrumentation, Springer Link.

e.MAPPING WITH PROGRAM OUTCOMES:

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	H	H	H	M	H	H	H	H
CO2	M	M	M	H	H	H	H	H
CO3	H	M	H	H	H	H	H	H
CO4	H	M	H	H	H	H	H	H
CO5	H	H	H	H	H	H	H	H

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	H	M	H	H	H	H
CO2	M	M	M	H	H	H	H	H
CO3	H	M	H	H	H	H	H	H
CO4	H	M	H	H	H	H	H	H
CO5	H	H	H	H	H	H	H	H

Core 12: SPECTROSCOPY (Practical)

L	T	P	C
-	-	2	1

a. Course Code:
PPHL12

b. Course Objectives

- To measure the atomic spectra and various molecular spectra and analyse the spectra and interpret the spectra.

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Explain the working principle of different atomic and molecular spectroscopic instruments	**K2**
CO2:	Analyse and assign the modes of Raman and IR spectra	**K4**
CO3:	Determine force constant and Lande's splitting factor	**K5**

d. List of Experiments (Any Seven)

1. Measurement of Hydrogen spectral line – Balmer series
2. Measurement of alkali and Alkaline earth atomic spectra
3. Measurement of UV-Visible spectra of solvents

4. Measurement of band gap of nanomaterials/bulk/thin films

5. Estimation of the molecular parameters such as Bond Length, Bond Angle, Dipole Moment from Rotation Spectra

6. Mode assignment of the IR spectra of H_2O and C_6H_6

7. Mode assignment of the Raman spectra of $CHCl_3$ and CCl_4 and determination of depolarisation ratio of the modes

8. Remote analysis of atmospheric gases like N_2O using FTIR by National Remote Sensing Centre (NRSC), India

9. Determination of molecular structure from NMR spectra

10. Determination Lande's splitting factor from ESR spectrometer

11. Determination of force constant of HCl from IR spectra

12. Measurement of Raman spectra of carbon based materials

13. Any other experiment

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of Cos

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 (K3)	H	L	L	M	M	H	L	L
CO2 (K4)	H	M	M	H	M	H	L	L
CO3(K5)	H	L	L	L	M	M	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1 (K3)	H	L	L	L	H	H	M	M
CO2 (K4)	H	L	L	L	H	H	L	L
CO3 (K5)	H	L	L	M	H	H	L	L

(L – Low, M – Medium, H – High; K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5–Evaluate, K6-Create)

Group - II
ELECTIVE COURSES: Theory courses

(a) Thin film Physics
(b) Materials Science
(c) Medical Physics

(a) THIN FILM PHYSICS

a. Course Code:

L	T	P	C
3	0	0	3

b. Course Objectives

- To obtain a thorough understanding of the ideas and practices of thin film deposition.
- To educate students the general concepts in deposition techniques
- To learn the fundamentals of both the microstructure that has been created during the deposition process and the thin film growth process.
- To learn how to design thin film systems and choose suitable deposition methods depending on the composition, microstructures, and properties of the materials.
- It will stimulate the students to understand the design and functioning of Thin film applications.

c. Learning Progression:
Film properties, Optical properties, Electrical properties, Interference, Crystal growth, oxidation, reduction, compound formation, solution growth

d. Theoretical/Experimental Foundations of the course:

- Awareness of interference, materials, surface, substrate
- Knowledge about deposition technolgies
- A detailed knowledge in characteristic properties of film

e. Course Outcomes (COs)

CO1: Provide suitable deposition techniques for the targeted thin film structure with the desired attributes.

CO2: Become well-versed in the fundamentals of the various film deposition techniques.

CO3: To measure the thickness of various thin films and describe their optical characteristics, use the appropriate Techniques.

CO4: Become thoroughly knowledgeable about the overall procedure for growing thin films and assess how the Microstructure changed after deposition.

CO5: To assist students in achieving a thorough conceptual understanding of the film growth for Application purposes.

f. Course Outline:

UnitI: **Physics of Surfaces, Interfaces and Thin films**

Module 1.1**:**Introduction to Thin films, Mechanism of thin film formation: Condensation and nucleation, growth and coalescence of islands, Crystallographic structure of films, factors affecting structure and properties of thin films

Module 1.2: Properties of thin films:- Transport and optical properties ofmetallic, semiconducting and dielectric films; Application of thin films. (9 hrs)

Unit II: **Thin films preparation &Thickness measurement**

Module 2.1: Methods of Preparation/synthesis of Thin films: Vacuum evaporation, Cathode sputtering, Anodicoxidation, Plasmaanodization, Chemical vapour deposition(CVD), Ion-assisteddeposition (IAD), Laserablation, Longmuir Blochetfilm, Sol-gel film deposition.

Module 2.2: Thickness measurements: Resistance, capacitance, microbalance, Quartz crystal - Thickness monitor, Optical absorption, Multiple beam interference, Interference colour, Ellipsometry methods. (12 hrs)

Unit III: **Physical Vapour Deposition**

Module 3.1: Substrate preparation – Thermal evaporation method – Electron beam evaporation – Pulsed laser deposition

Module 3.2**:** Web coating – Ion beam assisted evaporation – DC sputtering – RF sputtering method – Magnetron sputtering (9 hrs)

Unit IV**: Chemical Method**

Module 4.1: Solution growth of thin films–Spray pyrolysis–Electro deposition of Semiconducting and polymer films

Module 4.2: Chemical vapour deposition: Pyrolysis, Reduction, Oxidation, Compound formation, Disproportionation – Thermodynamics of CVD: Reaction feasibility, Conditions of equilibrium (12 hrs)

Unit V: **Thin films for Devices & other Applications:**

Module 5.1**:**Dielectric deposition- silicon dioxide, silicon nitride, silicon oxynitride, polysilicon deposition, metallization, electromigration, silicides.

Module 5. 2:Thin film transistors, thin film multilayers, optical filters, mirrors, sensors and detectors. (9 hrs)

g.Book for study:

1. A.Goswami–ThinFilmFundamentals–NewAgeInternational,1996.
2. LudmilaEckertova,Physicsofthinfilms,2nd Revisededition,PlenumPress,NewYork,1986 (Reprinted1990),
3. K.L.Chopra,Thinfilmphenomena,Mc-GrawHill,NewYork,1969.

h.Books for references:

1. MiltonOhring–MaterialsScienceofThinFilms–AcademicPress,SecondEdition,2002.
2. L.C.FeldmanandJ.W.Mayer,FundamentalsofsurfaceandThinFilmsAnalysis,NorthHolland,Amsterdam,1986.
3. S.M.Sze,SemiconductorDevices-PhysicsandTechnology,JohnWiley,1985.
4. R.W.Berry,P.M.HallandM.T.Harris,Thinfilmtechnology,VanNostrand,NewJersey,1970,K.L.Chopra and LK.Malhotra(ed),
5. ThinFilmTechnologyandApplications,T.M.H.PublishingCo.,NewDelhi(1984).
6. LI.MaisselandR.Gland–Handbookofthinfilmtechnology–McGrawHillbookcompany,NewYork1983.
7. A.Chambers,R.K.Fitch,B.S.Halliday–BasicVacuumTechnology–OverseasPress,NewDelhi,2005.

i. Mapping of Cos to POs and PSOs

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1(K1)	H	H	H	M	M	M	H	M
CO2(K2)	M	M	M	H	L	H	H	L
CO3(K3)	M	M	M	H	H	H	M	M
CO4(K4)	H	M	M	H	M	M	M	M
CO5(K5)	H	L	M	M	M	H	M	M
CO6(K6)	H	L	M	L	H	L	M	L

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1(K1)	H	L	M	M	H	H	L	M
CO2(K2)	M	L	M	M	M	L	M	L
CO3(K3)	L	M	M	H	H	H	L	M
CO4(K4)	M	L	L	M	M	L	M	M
CO5(K5)	H	L	L	H	H	M	M	M
CO6(K6)	L	L	L	L	H	M	L	L

(L–Low,M–Medium,H–High;K_1–Remember,K_2–Understand,K_3–Apply,K_4–Analyze,K_5–Evaluate,K_6–Create).

(b) MATERIALS SCIENCE

L	T	P	C
3	0	0	3

a.Course Objectives

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

b. Course Outcomes (COs)

At the end of the Course, the student will be able to -

CO1:	Acquire knowledge on optoelectronic materials	**K1**
CO2:	Be able to prepare ceramic materials	**K3**
CO3:	Be able to understand the processing and applications of polymeric materials	**K2, K3**
CO4:	Be aware of the fabrication of composite materials	**K5**
CO5:	Be knowledgeable of shape memory alloys, metallic glasses and nanomaterials	**K1**

d. Course Outline:

UNIT I: OPTOELECTRONIC MATERIALS

Importance of optical materials – properties: Band gap and lattice matching – optical absorption and emission – charge injection, quasi-Fermi levels and recombination – optical absorption, loss and gain. Optical processes in quantum structures: Inter-band and intra-band transitions Organic semiconductors. Light propagation in materials – Electro-optic effect and modulation, electro-absorption modulation – exciton quenching.

UNIT II CERAMIC MATERIALS

Ceramic processing: powder processing, milling and sintering – structural ceramics: zirconia, almina, silicon carbide, tungsten carbide – electronic ceramics – refractories – glass and glass ceramics

UNIT III POLYMERIC MATERIALS

Polymers and copolymers – molecular weight measurement – synthesis: chain growth polymerization – polymerization techniques – glass transition temperature and its measurement – viscoelasticity – polymer processing techniques – applications: conducting polymers, biopolymers and high temperature polymers.

UNIT IV COMPOSITE MATERIALS

Particle reinforced composites – fiber reinforced composites – mechanical behavior – fabrication methods of polymer matrix composites and metal matrix composites – carbon/carbon composites: fabrication and applications.

UNIT V: NEW MATERIALS

Shape memory alloys: mechanisms of one-way and two-way shape memory effect, reverse transformation, thermo-elasticity and pseudo-elasticity, examples and applications -bulk metallic glass: criteria for glass formation and stability, examples and mechanical behavior -

nanomaterials: classification, size effect on structural and functional properties, processing and properties of Nano crystalline materials, single walled and multi walled carbon nanotubes

TEXT BOOKS

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

REFERENCE BOOKS

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

e. MAPPING WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	M	H	H	M	M	M	M	L
CO2	M	H	H	M	M	M	M	L
CO3	M	H	M	M	M	M	M	M
CO4	L	H	M	H	M	H	M	M
CO5	M	H	M	M	M	M	M	M

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	M	H	H	M	M	M	M	L
CO2	M	H	H	M	M	M	M	L
CO3	M	H	M	M	M	M	M	M
CO4	L	H	M	H	M	H	M	M
CO5	M	H	M	M	M	M	M	M

(c) MEDICAL PHYSICS

L	T	P	C
3	0	0	3

a.Course Objectives

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

c. Course Outcomes (COs)

At the end of the Course, the student will be able to -

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

d. Course Outline:

UNIT I: X-RAYS AND TRANSDUCERS

Electromagnetic Spectrum – Production of X-Rays – X-Ray Spectrum –Bremsstrahlung – Characteristic X-Ray – X-Ray Tubes – Coolidge Tube – X-Ray Tube Design – Thermistors – photo electric transducers – Photo voltaic cells – photo emissive cells –Photoconductive cells– piezoelectric transducer

UNIT II: BLOOD PRESSURE MEASUREMENTS

Introduction – sphygmomanometer – Measurement of heart rate – basic principles of electrocardiogram (ECG) –Basic principles of electro-neurography (ENG) – Basic principles of magnetic resonance imaging (MRI)

UNIT III: RADIATION PHYSICS

Radiation Units – Exposure – Absorbed Dose – Rad to Gray – Kera Relative Biological Effectiveness –Effective Dose – Sievert (Sv) – Inverse Square Law – Interaction of radiation with Matter – Linear Attenuation Coefficient – Radiation Detectors –Thimble Chamber – Condenser Chambers – Geiger Counter – Scintillation Counter

UNIT IV: MEDICAL IMAGING PHYSICS

Radiological Imaging – Radiography – Filters – Grids – Cassette – X-Ray Film – Film processing – Fluoroscopy – Computed Tomography Scanner – Principal Function – Display – Mammography – Ultrasound Imaging – Magnetic Resonance Imaging – Thyroid Uptake

System – Gamma Camera (Only Principle, Function and display)

UNIT V: RADIATION PROTECTION

Principles of Radiation Protection – Protective Materials – Radiation Effects – Somatic – Genetic Stochastic and Deterministic Effect – Personal Monitoring Devices – TLD Film Badge – Pocket Dosimeter.

TEXT BOOKS

1. Dr. K. Thayalan , *Basic Radiological Physics*, Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi, 2003.

2. Curry, Dowdey and Murry, *Christensen's Physics of Diagnostic Radiology: - Lippincot*Williams and Wilkins, 1990.

3. FM Khan, *Physics of Radiation Therapy*, William and Wilkins, 3rd ed, 2003.

4. D. J. Dewhurst, *An Introduction to Biomedical Instrumentation*, 1st ed, Elsevier Science, 2014.

5. R.S. Khandpur, *Hand Book of Biomedical Instrumentations*, 1st ed, TMG, New Delhi, 2005.

REFERENCE BOOKS

1. Muhammad Maqbool, *An Introduction to Medical Physics*, 1st ed, Springer International Publishing, 2017.
2. Daniel Jirák, FrantišekVítek, *Basics of Medical Physics*, 1st ed, Charles University, Karolinum Press, 2018
3. Anders Brahme, *Comprehensive Biomedical Physics*, Volume 1, 1st ed, Elsevier Science, 2014.
4. K. Venkata Ram, *Bio-Medical Electronics and Instrumentation*, 1st ed, Galgotia Publications, New Delhi, 2001.
5. John R. Cameron and James G. Skofronick, 2009, Medical Physics, John Wiley Interscience Publication, Canada, 2nd edition.

e.MAPPING WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	H	H	H	L	L	M	H	H
CO2	H	H	H	M	L	M	H	H
CO3	H	H	H	M	L	M	H	H
CO4	H	H	H	M	L	M	H	H
CO5	H	H	H	L	L	M	H	H

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	H	H	H	L	L	M	H	H
CO2	H	H	H	M	L	M	H	H

CO3	H	H	H	M	L	M	H	H
CO4	H	H	H	M	L	M	H	H
CO5	H	H	H	L	L	M	H	H

SKILL COURSES – Practical course – Fourth Semester

Group – 2

(a) PIC Microcontroller - Applications
(b) NI LabVIEW - Applications

(a) PIC Microcontroller - Applications

L	T	P	C
-	-	2	1

a. **Course Code:**
PPHSAA

b. **Course objectives:**
- To teach functioning of computer, microcontroller architecture, programming and compiling
- To construct two applications based PIC16F877a microcontroller

c. **Course Outcome**

On the successful completion of the value added course, the learner will be able to

CO1: Explain the working microprocessor and microcontroller systems (K2)

CO2: Write program for desired applications in development software and in hardware (K4)

CO3: Construct any two specialised application as real device and demonstrate its function (K6)

d. **Course outline (contact hours: 15)**

Module 1: Personal computer – word-processor operation – Microprocessor systems – microcontroller Applications (3 hours)
Module 2: Microcontroller architecture – program operations (4 hours)
Module 3: Hardware design – program execution – assembly language (4 hours)

Module 4: Program development – MPLAB IDE (4 hours)

Applications (Any Two applications only)

1. Servo Motor control using PIC16F877a
2. Interfacing humidity and temperature sensors with PIC16F877a
3. Any other application by student's choice
4. Any other application suggested by the course teacher

Book for Reference:

1. Martin Bates, PIC Microcontrollers-*An Introduction to Microelectronics,* Third Edition (2011), Elsevier, Oxford.
2. https://www.microchip.com/en-us/education/academic-program
3. https://www.microchip.com/en-us/tools-resources/develop/mplab-x-ide

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1(K2)	H	L	H	L	L	L	H	M
CO2(K4)	H	L	H	L	M	L	H	M
CO3(K6)	H	L	H	L	L	L	H	M

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1(K2)	H	L	H	L	L	L	H	L
CO2(K4)	H	L	H	L	M	L	H	L
CO3(K6)	H	L	H	L	L	L	H	L

(b) NI LabVIEW - APPLICATIONS

L	T	P	C
-	-	2	1

a. **Course Code:**
PPHSAB

b. **Course objectives:**

- To teach graphical representation data acquisition and measurement control
- To create two applications using their own programme

c. Course Outcome

On the successful completion of the value added course, the learner will be able to

CO1: Explain the working NI virtual instrument functions (K2)

CO2: Write program for desired applications in software and using hardware (K4)

CO3: Construct any two specialised application as real device and demonstrate its function (K6)

d. Course outline (contact hours: 15)

Module 1: Building virtual instrument fundamentals, Data types and their graphical representation

in user interfaces (3 hours)
Module 2: Digital and analog I/O and internal functions (3 hours)
Module 3: Building control panel and using VI (3 hours)
Module 4: Installing and configuring data acquisition hardware – data acquisition concepts – Triggering (3 hours)

Applications (Any two applications only)
1. Thermocouple Data Acquisition program
2. Temperature control of furnace
3. Measurement of current and voltage from analog meters through compact DAQ
4. Any other application by student's choice
5. Any other application suggested by the course teacher

Book for Reference:

1. Getting Started with LabVIEW, National Instruments, July 2000 Edition
   Part Number 321527D-01
2. Data Acquisition Basic Manual, National Instrument, January 1998 Edition
   Part Number 320997C-01
3. https://www.ni.com/en-in/support/downloads/software-products/download.labview-student-software-suite.html#352828
4. https://www.ni.com/docs/en-S/bundle/labview/page/lvhowto/lv_getting_started.html

e. Mapping of COs to POs & PSOs with correlation level and Cognitive level of COs

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1(K2)	H	L	H	L	L	L	H	H
CO2(K4)	H	L	H	L	M	L	H	H
CO3(K6)	H	L	H	L	L	L	H	H

CO\PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1(K2)	H	L	H	L	L	L	H	H
CO2(K4)	H	L	H	L	M	L	H	H
CO3(K6)	H	L	H	L	L	L	H	H

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