DEPARTMENT OF PHYSICS
M. Tech in Advanced Materials Science and Technology

CURRICULUM

SEMESTER-I

Sl. No.	Subject Code	Subject	L - T - P	Credit
1	PH1001	Fundamentals of Materials Science	3 - 1 - 0	4
2	PH1002	Mechanical Behavior of Materials	3 - 1 - 0	4
3	PH1003	Optoelectronic Materials and Devices	3 - 1 - 0	4
4	*****	Elective - I	3 - 1 - 0	4
5	*****	Elective - II	3 - 1 - 0	4
6	PH1051	General Materials Science Lab	0 - 0 - 4	2
7	PH1052	Materials Synthesis & Characterization Lab	0 - 0 - 4	2
				24

SEMESTER-II

Sl. No.	Subject Code	Name of the Subject	L - T - P	Credit
1	PH2001	X-ray Diffraction & Structure of Materials	3 - 1 - 0	4
2	PH2002	Nano materials – Science & Technology	3 - 1 - 0	4
3	*****	Elective - III	3 - 1 - 0	4
4	*****	Elective - IV	3 - 1 - 0	4
5	*****	Elective - V	3 - 1 - 0	4
6	PH2051	Computational Lab	0 - 0 - 4	2
7	PH2052	Seminar-I (Non-Project)/Sessional	0 - 0 - 2	1
8	PH2053	Project-I	0 - 0 - 2	1
				24

SEMESTER-III

Sl. No.	Subject Code	Name of the Subject	Credit
1	PH3051	Project-II	11
2	PH3052	Project Seminar-I	02
			13

SEMESTER-IV

Sl. No.	Subject Code	Name of the Subject	Credit
1	PH4051	Project-III	11
2	PH4052	Project Seminar-II & Viva Voce	03
			14
		Total Programme Credit	**75**

Electives Subjects:

Sl.	*Subject Code*	*Name of the Subject*

No.		
1	PH9011	Materials for Engineering Applications
2	PH9012	Numerical Analysis & Software Applications in Materials Science
3	PH9013	Semiconductor Materials and Device Technology
4	PH9014	Non-linear Optical Materials and Characterizations
5	PH9015	Techniques of Materials Characterization
6	PH9016	Thin-film Materials Technology
7	PH9017	Liquid Crystalline Materials
8	PH9018	Composite Materials
9	PH9019	Nuclear Reactor Materials
10	PH9020	Mechanical Behavior and Strong Materials
11	PH9021	Magnetic Properties and Magnetic Materials
12	PH9022	Fiber-optic Systems
13	PH9023	Electron Optics & Microscopy

SUMMARY OF COURSES

Subject code	Name of the Subject	L - T - P	Credit	Name of the developer
PH1001	Fundamentals of Materials Science	3 - 1 - 0	4	Prof. A. K. Meikap& Dr S. Sahoo
PH1002	Mechanical Behavior of Materials	3 - 1 - 0	4	Dr. S. Basu& Dr. A. Mondal
PH1003	Optoelectronic Materials and Devices	3 - 1 - 0	4	Prof. P. Kumbhakar & Dr. H. Chaudhuri
PH2001	X-ray Diffraction & Structure of Materials	3 - 1 - 0	4	Dr. H. Chaudhuri
PH2002	Nano materials – Science & Technology	3 - 1 - 0	4	Dr. A. Mondal

Electives Subjects:

Subject Code	Name of the Subject	L-T-P	Credit	Name of the developer
PH9011	Materials for Engineering Applications	3 - 1 - 0	4	Dr. A. K. Chakraborty
PH9012	Numerical Analysis & Software Applications in Materials Science	3 - 1 - 0	4	Dr. M. K. Mandal
PH9013	Semiconductor Materials and Device Technology	3 - 1 - 0	4	Dr. A. Mondal & Prof. A. K. Meikap
PH9014	Non-linear Optical Materials and Characterizations	3 - 1 - 0	4	Prof. P. Kumbhakar

PH9015	Techniques of Materials Characterization	3 - 1 - 0	4	Dr. A. K. Chakraborty
PH9016	Thin-film Materials Technology	3 - 1 - 0	4	Prof. A. K. Meikap
PH9017	Liquid Crystalline Materials	3 - 1 - 0	4	-
PH9018	Composite Materials	3 - 1 - 0	4	-
PH9019	Nuclear Reactor Materials	3 - 1 - 0	4	-
PH9020	Mechanical Behavior and Strong Materials	3 - 1 - 0	4	-
PH9021	Magnetic Properties and Magnetic Materials	3 - 1 - 0	4	-
PH9022	Fiber-optic Systems	3 - 1 - 0	4	Dr. M. K. Mandal
PH9023	Electron Optics & Microscopy	3 - 1 - 0	4	-

Sub Discipline: LABORATORY& SESSIONAL COURSES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
PH1051	General Materials Science Lab	0 - 0 – 4	2
PH1052	Materials Synthesis & Characterization Lab	0 - 0 – 4	2
PH2051	Computational Lab	0 - 0 – 4	2
Sub Discipline: PROJECT, SEMINAR etc.			
PH2052	Seminar-I (Non-Project)/Sessional	0 - 0 – 2	1
PH2053	Project-I		1
PH3051	Project-II		11
PH3052	Project Seminar-I		02
PH4051	Project-III		11
PH4052	Project Seminar-II & Viva Voce		03

Department of Physics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PH1001	**Fundamentals of Materials Science**	PCR	3	1	0	4	3

<table>
<tr><td colspan="2">Pre-requisites</td><td>Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td>CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">CO1: To demonstrate basic knowledge of various material properties.
CO2: To summarize various structural, electrical, thermal and magnetic properties of materials.
CO3: To exhibit knowledge of different techniques to characterize materials.</td></tr>
<tr><td>Topics Covered</td><td colspan="2">Topic 1: Crystal elasticity and lattice dynamics, Elastic stiffness and compliance coefficients, second and third order elastic constants, Cauchy relations, strain energy function, Theory of lattice vibration, Born Karman condition, phonon frequency distribution and dispersion relations, interaction of X-rays and neutrons with phonons. [15]
Topic 2: Debye Waller factor and Mossbauer effect. [8]
Topic 3: Thermodynamic functions and relations for a crystal. Phase transformations & multiphase equilibrium. [8]
Topic 4: Electronic energy band theory, classical free electron theory of solids, Sommerfeld quantum free electron theory of a solid, Bloch wave-functions for a periodic potential, Kronig-Penny model and energy bands. Fermi energy and Fermi surfaces, effective mass of an electron, Brillouin zones & Reciprocal lattice. Many electron theories. [13]
Topic 5: Electronic properties of Solids, Transport equation in presence of magnetic field, cyclotron resonance, energy levels and density of states in presence of magnetic fields. Landau diamagnetism and de-Haas van-Alphen effect. Hall effect and magnetoresistance. Paramagnetism. [12]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="2">Text Books:
1. Ashcroft & Mermin – Solid State Physics
2. Animalu – Intermediate Quantum Theory of Crystalline Solids
Reference Books:
1. Rogadski & Palmer - Solid State Physics
2. Pines – Elementary Excitations in Solids
3. Wallace – Thermodynamics of Crystals.</td></tr>
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Department of Physics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PH1002	**Mechanical Behavior of Materials**	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: To understand the mechanical properties of materials from a fundamental physics perspective. • CO2: To classify different types of defects and infer their influence on the mechanical properties of the materials. • CO3: To model the failure of crystalline materials and suggest ways to strengthen their mechanical properties.
Topics Covered	**Topic 1:** Introduction to deformation behaviour: Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress - strain response for metal, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of strength of materials. **[10]** **Topic 2:** Elasticity Theory: The State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metals, ceramics and polymers. **[5]** **Topic 3:** Yielding and Plastic Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity, plastic deformation of metals **[10]** **Topic 4:** Microscopic view of plastic deformation: crystals and defects, classification of defects, thermodynamics of defects, geometry of dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity, Hall-Petch breakdown, dislocations in ceramics and glasses. **[10]** **Topic 5:** Fracture: fracture in ceramics, polymers and metals, different types of fractures in metals, fracture mechanics - Linear fracture mechanics -KIC, elasto-plastic fracture mechanics - JIC, Measurement and ASTM standards, Design based on fracture mechanics, effect of environment, effect of microstructure on KIC

	and JIC, application of fracture mechanics in the design of metals, ceramics and polymers. **[8]** **Topic 6:** Deformation under cyclic load - Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, ceramics and polymers**.** **[5]** **Topic 7:** Deformation at High temperature: Time dependent deformation - creep, different stages of creep, creep and stress rupture, creep mechanisms and creep mechanism maps, creep under multi-axial loading, microstructural aspects of creep and design of creep resistant alloys, high temperature deformation of ceramics and polymers. **[8]**
Text Books, and/or reference material	**Text Books:** **1.** Mechanical Metallurgy – George E. Dieter **2.** Mechanical Behavior of materials – Thomas H. Courtney **Reference Books:** 1. Strong solids – A. Kelly 2. Materials Science and Engineering – William D. Callister, Jr. 3. Mechanics of composite materials – Autar K. Kaw

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH1003</td><td>Optoelectronic Materials and Devices</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the working principle of laser, electro-optic devices and communication of light in optical fiber.
• CO2: Describe the mechanism of absorption, amplification, broadening of radiation and technique of generation of short pulsed laser radiation.
• CO3: Calculate the lasing threshold, E-field and intensity distribution function of transverse mode.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Basic principles of Laser, broadening of energy levels, Absorption and amplification of light in a medium, population inversion and threshold condition for a laser, gain coefficient; Laser Rate Equations, 2-level, 3-level and 4-level Lasers, expression of Gain/Loss coefficient, Threshold population, Saturation Intensity etc. [10]
Topic 2: Line broadening Mechanisms, Spontaneous transition, Collision Broadening and Doppler Broadening. [5]
Topic 3: Resonators, Stability of resonators, g parameters, various types of resonators, Modes of Laser Radiation, Longitudinal and transverse modes, Mode selection techniques, Gaussian beam propagation Gaussian beam focusing. [10]
Topic 4: Different types of lasers, Principles of operations of Ruby Laser, He-Ne laser, Nd:YAG laser, Ti:Sa laser, CO_2 laser etc. [6]
Topic 6: “Q-switching & mode-locking, different methods of Q-switching, mechanisms and their comparison, methods of mode-locking. [5]
Topic 7: Electro-optic effect, acousto-optic effect, electro-optic retardation, electro-optic amplitude modulation, phase-modulation of light. [10]
Topic 8: Optical fibre waveguide: step index and graded index fibre, multimode and single mode fibre, attenuation mechanisms in fibres etc. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. O. Svelto, Principles of Lasers
2. A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press (2003)
Reference Books:
1. W. Koechner, Solid State Laser Engineering
2. A. Yariv, Quantum Electronics
3. J. Wilson and J. F. B. Hawkes, Optoelectronics: An introduction, Prentice Hall of India Pvt. Ltd., 2nd ed.-2004
4. Pallab Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall</td></tr>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH1051</td><td>General Materials Science Lab</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To perform experiments to understand fundamental concepts of material science.
CO2: To exhibit operating knowledge of devices used for material characterization.
CO3: To relate the concepts learned with the functioning of everyday devices.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Band Gap Measurement of semiconductor
2. Determination of Refractive index by Abbe refractrometer of different liquid samples
3. Determination of Gaussian beam distribution of He-Ne Laser beam
4. To study the hall effect of a given semiconductor materials
5. To determine the Hysteresis loop of a ferromagnetic materials
6. To determine magneto resistance of n-type semiconductor materials
7. To study the Electrolytic conduction of ionic crystals
8. Determination of efficiency of a solar cell</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. An advanced course in practical physics, Chattapadhyay and Rakshit.
2. Advanced practical Physics, K. G. Mazumdar.

Reference Books:
1. A Textbook of Advanced Practical Physics, S. K. Ghosh.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH1052</td><td>Materials Synthesis & Characterization Lab</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To perform experiments to understand fundamental concepts of polymers and semiconductors.
CO2: To exhibit operating knowledge of devices used for material synthesis.
CO3: To relate the concepts learned with the functioning of everyday devices.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Synthesis of a polymer composite
2. Synthesis of a semiconductor nanoparticles by chemical method
3. Preparation of metal oxide semiconductor thin film
4. Determination of optical absorption characteristics
5. Electrical transport properties of polymer composite
6. Electrical transport properties of thin film
7. Determination of thermal stability of polymer composite
8. Structural characterization of nanomaterials by XRD technique
9. Spectral characterization of Si & Ge photo detectors</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. An advanced course in practical physics, Chattapadhyay and Rakshit.
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH2001</td><td>X-ray Diffraction & Structure of Materials</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To demonstrate knowledge on X-ray diffraction techniques for characterizing materials (crystalline, amorphous, quasi-crystalline, polymer, nanomaterials).
• CO2: To list different techniques for extracting quantitative information about material structures by x-ray diffraction.
• CO3: To develop an understanding of the theory of X-ray diffraction and to employ it to study novel material structures.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Recapitulation: Production and properties of X-ray. X-ray absorbtion, absorbtion edges, mass absorbtion coefficients. Filtering of characteristic spectra. Symmetry operations, Macroscopic symmetry, Point Group of symmetry, Microscopic symmetry, Space Group, Hermann-Mauguin symbols of Space Group. Bravais Lattice. Short-range and long-range order, Single crystal and polycrystalline state of matter. [12]
Topic 2: X-ray diffraction: Kinematical theory. Scattering by an electron, atom, atomic scattering factor, scattering by a conglomerate of atoms in regular order, scattering by a crystal, crystal structure factor, Reciprocal lattice, relations between reciprocal lattice and direct lattice vectors. Ewald’s sphere, Laue conditions, Bragg’s Law, Laws of systemic absences from different crystal systems. Phase identification by Hanawalt’s method. Quantitative estimation of different paphases, some important applications. [12]
Topic 3: Scattering by conglomerate of atoms arranged irregularly, scattering by amorphous materials and liquids. Radial Distribution analysis. [7]
Topic 4: Scattering by large perfect crystals, Dynamical theory of X-ray diffraction, X-ray microscopy, Lang Camera, direct observation of defect parameters. Diffraction from polycrystalline materials. Fourier analysis of the diffraction profiles. Estimation of defect parameters from Four line shape analysis. [8]
Topic 5: Effect of temperature on diffraction, Change of phase due to heat treatment. Diffusion mechanism. Time-temperature transformations of some important alloys. [6]
Topic 6: Change of perfect polycrystallinity by mechanical processes, rolling Texture, The importance of its study, Poly figure and its determination. [6]
Topic 7: Quasi crystalline states of matter and their analysis. Nano materials, their characteristic properties and some of their uses. [5]</td></tr>
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Text Books, and/or reference material	**Text Books:** 1. S. K. Chatterjee, X-ray diffraction its theory and applications 2. B. D. Cullity, X-ray diffraction **Reference Books:** 1. M. M. Woolfson, An introduction to X-ray crystallography 2. L. V. Azaroff, Elements of X-ray crystallography 3. B. E. Warren, X-ray diffraction

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH2002</td><td>Nano materials – Science & Technology</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="7">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: To outline the techniques of synthesis and characterization of nanomaterials.
• CO2: To apply different microscopic techniques and tools to characterize nanomaterials.
• CO3: To select appropriate nanomaterials and their characterization techniques for solving real life engineering problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Topic 1: Nanostructure materials, Determination of energy Eigen values for 1D, 2D and 3D nanostructure by solving the Schrodinger equation. Calculation of density of state function of 1D, 2D and 3D nanostructures, properties nanomaterials. [5]
Fabrication methods: Discussion on Top down and bottom up method.
Mechanical technique: Ball milling method. [2]
Bottom up method:
Physical vapour deposition technique: Thermal evaporation, e-beam evaporation, laser ablation technique, vapour-liquid-solid (VLS) deposition technique. Application of Oblique Angle Deposition and Glancing Angle Deposition (GLAD) techniques for nanostructure fabrication.
CVD technique for nanostructure fabrication, MBE technique for nanostructure fabrication. [9]
Chemical methods: sol-gel technique [3]
Langmuir–Blodgett film growth technique. [2]
Top down method:
Chemical and dry etching technique, Optical and electron beam lithography, focus ion beam method. [9]
Topic 2: Characterization of nanomaterials: Field-emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), grazing angle x-ray diffraction (GXRD). [5]
Topic 3: Measurement of mechanical properties, thermal properties, magnetic properties, dielectric and electronic properties. [7]
Topic 4: Inorganic semiconductor nanostructures, fabrication, characterization and application. Nanomagnetic materials and devices. [6]
Topic 5: Inorganic nanomaterials, organic semiconductor nanomaterials, bio-nanotechnology. Micromachining tools for nanosystems. [4]
Topic 6: MEMS design. [4]</td></tr>
<tr><td>Text Books,</td><td colspan="8">Text Books:</td></tr>
</table>

and/or reference material	1. S. Kulkarni, Nanotechnology; Principles and Practices, Capital Publishing **2.** Robert W. Kelsall , Ian W. Tlamley, Mark Geoghegan; Nanoscale Science and Technology **Reference Books:** **1.** S. C. Tjong, Nanocrystalline Materials, Elsevier 2. Claire Dupas, Philippe Houdy, Marcel Lahmani, Nanoscience Nanotechnology and Nanophysics 3. Hoshino & Mishima, Nanomaterials from Research to Applications, Elsevier

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH2051</td><td>Computational Lab</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To demonstrate capability to understand and write computer programs
• CO2: To exhibit knowledge of modeling of simple physical systems.
• CO3: To develop an understanding of fundamental concepts and equations of his chosen field through computational simulations.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction to MATLAB
2. To Plot the Fermi- Dirac Probability distribution vs Energy Characteristics of an intrinsic semiconductor at room temperature using MATLAB
3. To Plot the Fermi- Dirac Probability distribution vs Energy Characteristics of n-type semiconductor at room temperature using MATLAB
4. To Plot the Fermi- Dirac Probability distribution vs Energy Characteristics of p-type semiconductor at room temperature using MATLAB
5. To plot the carrier concentration vs temperature characteristics for an intrinsic semiconductor
6. Plotting of state variables (Phase space & state space) of a given dynamical system
7. Estimate of Hurst exponent and Lyapunov exponent (nonlinear statistics) of a dynamical system
8. Numerical solution of different integral and differential equations using Mathematica or MATLAB.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Book: (1) A First Course in Computational Physics, Paul L. DeVries, Javier E. Hasbun, ISBN: 978-0-7637-7314-4.

Reference Book: (1) Computational Physics , Landau Rubin H, ISBN: 9783527413157</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9011</td><td>Materials for Engineering Applications</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To outline different techniques for preparation and fabrication of engineering materials.
CO2: To explain different modern techniques for characterization of polymer, composite, glassy, electrical and optical materials.
CO3: To identify appropriate material types for solving real life engineering problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Materials: The material world, types of materials, Introduction to metals, ceramics, polymers, composites, semiconductors, their physical properties, and selection. [5]

Structural Materials: Metals and alloys, Ferrous alloys, Steel, the Phase rule and phase diagrams of Fe-C system and common non-ferrous alloys, Eutectic, Eutectoid, Peritectic diagrams, TTT diagram, the Liver rule. [12]

Polymers: Types of polymers, polymerizations processes, step polymerizations and addition polymerization, degradation and stabilization of polymers, conducting polymers, common polymers, their synthesis, properties and applications. [11]

Ceramics & glasses: Types of ceramics, phase diagrams of common ceramic alloys, properties of common ceramics & glasses, their common applications and processing methods. [7]

Composites: Types of composites, conventional composites, fiber reinforced composites, nanocomposites, property averaging by Rule of Mixture, isostress & isostrain loading, Interfacial strength, mechanism of reinforcement, common structural composites, their processing and applications. [8]

Electrical Materials: Conductors, Conductivity and its temperature dependency, semiconductors, Superconductors. [5]

Optical Materials: Optical properties, color, luminescence, reflectivity, transparency, opacity, etc., optical systems and devices, Laser materials, optical fibers, liquid crystal displays, photoconductors. [8]</td></tr>
<tr><td>Text Books, and/or reference</td><td colspan="7">Text Books:
1. J. F. Shackelford, M. K. Muralidhara, Introduction to Materials Science for Engineers</td></tr>
</table>

material	2. R. Balasubramaniam, *Callister's Materials Science & Engineering* 3. W.F. Smith, J. Hashemi, R. Prakash, *Materials Science & Engineering* 4. A. K. Bhargava, *Engineering Materials* **Reference Books:** 1. Rolf E. Hummel, *Understanding Materials Science : History, Properties, Applications* 2. John Martin, *Materials for Engineering* 3. J. Simmons, K Potter, *Optical Materials* 4. Fuxi Gan, *Laser Materials*

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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9012</td><td>Numerical Analysis & Software Applications in Materials Science</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To formulate algorithms for writing computer programs to solve problems numerically.
• CO2: To demonstrate proficiency of scientific software like MATLAB for formulating and solving problems related to the properties of materials and applications.
• CO3: To utilize knowledge of different tools for analyzing and interpreting data.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Problem solving algorithm, analysis of algorithms and programming, flow charts higher level languages. Basic syntax of C++, conditional and unconditional jumps, iteration, loops, functions. Basics of programming in C++, structure &object-oriented programming. [15]
Topic 2: Application of Programming to the following problems: Errors in numerical computation, Solutions of equations by iteration, Finite differences, Interpolation, Numerical integration and differentiation, Numerical solution of first and second order differential equations, Systems of linear equations, Methods of least squares, Matrix eigenvalues. [26]
Topic 3: Simulation techniques, nonlinear curve fitting, Use of software MATLAB for numerical & graphical computation. [15]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. A Stevens & Clayton Walnum, C++ Programming Bible
2. J H Mathews & K D Fink, Numerical Methods Using Matlab

Reference Books:
1. S BalachandraRao & C K Shantha, Numerical Methods with programs in BASIC, FORTRAN, Pascal and C++ .</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9013</td><td>Semiconductor Materials and Device Technology</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To recall different preparation techniques of single crystal and IC fabrication.
• CO2: To outline different advanced preparation techniques such as etching and lithography for high speed IC design process.
• CO3: To apply the fundamental knowledge of semiconductor materials to model dopant profile created by ion implantation technique.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic1: Preparation of electronic grade Si from metallurgical grade Si, Czochralski (CZ) method, Float zone method, Silicon wafer fabrication. [10]
Topic 2: Oxidation techniques, Growth kinetics, Oxide growth measurements techniques, Defects in silicon, silicon dioxide, Interface defects, Point defect-based model for oxidation, Polysilicon, Si_3N_4 and Silicide formation. [10]
Topic 3: Optical lithography, Deep UV lithography, Extreme UV lithography, Electron beam lithography, plasma and x-ray lithography techniques. [10]
Topic 4: Wet etching of Si and GaAs. Isotropic and anisotropic etching. Crystal orientation dependent etching. [7]
Dry etching, Classification of plasma etching techniques, reactive ion etching, Inductive couple plasma reactive ion etching technique etc. [6]
Topic 5: Diffusion and ion implantation, Diffusion in polycrystalline materials, Ion implantation techniques, Modelling and measurement of dopant profiles, Overview of process flow for IC technology. [13]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. S M Sze, Semiconductor Devices- Physics and Technology (2nd Ed.)
2. B G Streetman & S Banerjee, Solid State Electronic Devices

Reference Books:
1. S.K. Gandhi, VLSI fabrication principles</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9014</td><td>Non-linear Optical Materials and Characterization</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To illustrate propagation of electromagnetic waves in anisotropic optical media
• CO2: To calculate the conversion efficiency of different nonlinear optical (SHG, SFG & DFM) processes.
• CO3: To identify mechanisms of damage in non-linear media and ways to minimize them.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Electromagnetic wave propagation in anisotropic media, the dielectric tensor of an anisotropic medium, plane-wave propagation, uniaxial and biaxial crystals. [10]
Topic 2: Introduction to Nonlinear optics, Descriptions of nonlinear optical interactions, nonlinear susceptibility, classical anharmonic oscillator, Miller’s rule. [9]
Topic 3: Coupled-wave equation, sum-frequency mixing, difference-frequency generation, and parametric amplification, Manley-Rowe relations, phase-matching Techniques, nonlinear optical interactions with focussed Gaussian beams. [16]
Topic 4: Nonlinear optical materials, Organic and inorganic materials and their properties, chalcopyrite materials. Optical Kerr effect, Intensity dependent refractive index. [10]
Topic 5: Laser induced damage (introductory): Mechanism, dependencies of the damage threshold on the laser pulse duration, surface damage, bulk damage, and inclusion-induced damage in different linear and nonlinear optical materials. [11]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Y. R. Shen, The principles of Nonlinear Optics, Wiley, New York, 1984.
2. R. W. Boyd, Nonlinear Optics Academic Press Inc.

Reference Books:
1. F. Zernike and J. E. Midwinter, Applied Nonlinear Optics, Wiley, New York, 1973.
2. Edited by C. L. Tang, Methods of Experimental Physics, vol. 15, Quantum Electronics, Part- A. Yariv and P. Yeh, Optical waves in crystals.
3. V. G. Dmitriev, G. G. Gurzadyan, and D. N. Nikogosyan, Handbook of Nonlinear Optical Crystals, 2nd ed.</td></tr>
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Department of Physics								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PH9015	**Techniques of Materials Characterization**	PEL	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: To explain different tools and techniques for characterization of different materials. • CO2: To demonstrate knowledge of different optical and electron microscopic techniques (TEM, SEM, SPM) for characterization of different materials. • CO3: To demonstrate knowledge of different thermal methods (DTA, TGA, DSC, TMA and DMA) for characterization of different materials.
Topics Covered	**Topic1:** Materials characterization - definition; importance and application. Principles and general methods of compositional, structural and defect characterization. [**5**] **Topic 2:** Diffraction techniques - X-ray, electron and neutron diffraction **[7]** **Topic 3:** Microscopy - optical, electron (TEM & SEM) and electron microprobe analysis **[7]** **Topic 4**: Microscopy – scanning probe methods (STM, AFM, EFM, MFM etc.) **[5]** **Topic 5:** Optical spectroscopies - UV, visible, IR and Raman spectroscopies **[7]** **Topic 6:** Electron spectroscopies - Auger and photoelectron spectroscopies **[7]** **Topic 7:** Spin resonance spectroscopies - NMR, ESR and Mossbauer spectroscopies **[7]** **Topic 8:** Thermal methods - DTA, TGA, DSC, TMA and DMA. **[7]** **Topic 9:** Mechanical methods: measurement of tensile & flexural moduli, strength, fatigue, creep, fracture toughness, hardness etc. **[4]**
Text Books, and/or reference material	**Text Books:** 1. Materials Characterization Techniques- Sam Zhang, Lin Li, Ashok Kumar 2. Materials Characterization-Yang Lang 3. Auger and X-ray photoelectron spectroscopy- D. Briggs and M. P. Seah 4. An Introduction to Material Characterization- P. R. Khangaonkar **Reference Books:** 1. Characterization of Materials, (2 Volume Set), E. N. Kauffmann (Editor) 2. Physical Principles of Electron Microscopy- R. F. Egerton

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<tr><td>Lecture (L)</td><td>Tutoria l (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9016</td><td>Thin-film Materials Technology</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To recall the techniques of fabrication of different thin film materials.
• CO2: To illustrate different mechanisms of Vacuum Technology and epitaxial layer growth technology.
• CO3: To compare the working principles of PVD and CVD deposition systems and characterizations techniques of thin film.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Growth and structure of films. General features. Nucleation theories Effect of electron bombardment on film structure. Post- nucleation growth Epitaxial films and growth. Structural defects. [8]
Topic 2: Preparation methods: Electrolytic deposition, cathodic and anodic films, thermal evaporation, cathodic sputtering, chemical vapour deposition. Molecular beam epitaxy and laser ablution methods. [8]
Topic 3: Vacuum science and techniques: Vacuum principles; Vacuum generation - Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Cryo-Pump; Vacuum measurement - Thermal conductivity vacuum gauges, Ionization vacuum gauges. [8]
Topic 4: Thickness measurement and monitoring: Electrical, mechanical, optical interference, microbalance, quartz crystal methods.
Topic 5: Analytical techniques of characterization: Small angle X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy. [8]
Topic 6: Mechanical properties of films: Elastic and plastic behavior. Optical properties. Reflectance and transmittance spectra. Absorbing films. Optical constants of film material, Multilayer films, Anisotropic and gyrotropic films. [9]
Topic 7: Electric properties to films: Conductivity in metal, semiconductor and insulating films. Discontinuous films. Superconducting films. Dielectric properties. Magnetism of films: Molecular field theory. Spin wave theory. Anisotropy in magnetic films, [7]
Topic 8: Domains in films, Applications of magnetic films. [4]
Topic 9: Thin film devices: Fabrication and applications. [4]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. K.L. Chopra, Thin Film Phenomena; McGraw-Hill
2. A. Goswami; Thin Film Fundamentals; New Age International Pvt. Ltd

Reference Books:</td></tr>
</table>

	1. Thin Films; Heavens; Dover Publications Inc.; 1991 2. Thin-Film Deposition: Principles and Practice; Smith; McGraw-Hill; 1995 3. Handbook of Thin Film Technology; Maissel & Glang; McGraw-Hill; 1970

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9017</td><td>Liquid Crystalline Materials</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To demonstrate an understanding of the basic physics of liquid crystals.
• CO2: To name the basic phases and phase transitions of anisotropic liquid crystalline materials.
• CO3: To explain the various applications of liquid crystalline materials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Physical properties of liquid crystals and basic theory Phases and phase transitions; anisotropic materials; symmetry aspects; optics; electro optics of liquid crystals. [15]
Topic 2: Ferro and antiferroelectric liquid crystals; examples of LCs in nanoscience. [13]
Topic 3: Photonics and microwave electronics, overview of the research front. [13]
Topic 4: Liquid crystal applications LCDs, present and future displays, demonstrations, manufacturing of devices, non-display applications, thermochromics, Kevlar. [15]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. J. Prost, P.G. de Gennes: The physics of liquid crystals, Oxford 1993
2. P.J. Collings, Liquid Crystals Princeton university press, 2002.
Reference Books:
1. Vladimir G. Chigrinov, Vladimir M. Kozenkov, Hoi-Sing Kwok Photo-alignment of Liquid Crystalline Materials: Physics and Applications, Wiley, 2008.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9018</td><td>Composite Materials</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To acquire fundamental understanding of the composite materials.
• CO2: To analyze the design and performance of composite materials.
• CO3: To outline the fabrication and processing of metal matrix (MM), polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Introduction to composite materials along with its basic requirements and classification; Various models analyzing the design and performance of composite materials; Understanding the composite modulus, strength and fracture behaviour for structural applications. [18]
Topic 2: Composites including nano-composites for electrical, superconducting and device applications; Fabrication and processing of metal matrix (MM). [12]
Topic 3: Polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization; Fabrication of nano-composites. [13]
Topic 4: Secondary processing and joining of various composite materials for structural applications and their fracture behavior and safety. [13]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. K.K. Chawala, Composite materials, 2nd ed. Springer-Verlag, New York
2. P. M. Ajayan, L. S. Schadler, P. V. Braun, Nanocomposite Science and Technology, Wiley-VCH Verlag GmbH Co., Weinheim.
Reference Books:
1. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, Elsevier Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK.
2. K.K. Chawala, Ceramic matrix composites,1st ed., Chapman & Hall, London.
3. G. Piatti, Advances in composite materials, Applied Science Publishers Ltd., London.</td></tr>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutoria l (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9019</td><td>Nuclear Reactor Materials</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To show fundamental understanding of nuclear systems.
• CO2: To outline different modes of radiation damage in crystalline materials.
• CO3: To identify basic reactor materials, LWR core materials, and radiation growth.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Overview of Nuclear Systems Various types (LWR, PHWR, GCR, FBR, Fusion). [7]
Topic 2: Materials - Selection Nature of Materials Crystal Structure Imperfections Diffusion in Solids, Radiation Damage, Binary Elastic Collisions, Displacements due to PKA. [9]
Topic 3: Properties of Materials. Mechanical Properties. Fracture, Fatigue and Creep. SCC (& corrosion). [8]
Topic 4: Dislocation Theory. Types. Stress Fields and Strain Energy. Forces on Dislocations. Dislocation Interactions. Dislocation Sources and Pile-ups. Hardening: Dislocation. [8]
Topic 5: Precipitation, Grain-boundary, Solution, Strain. Radiation Effects. Microstructural Changes. Friction and Source Hardening. Fracture and DBTT. Embrittlement and Fracture. [10]
Topic 6: Reactor Materials, LWR Core Materials Radiation Growth - Zircaloys , Void Swelling (Stainless Steels). [7]
Topic 7: Radiation Induced vs Radiation Enhanced Creep. Pressure Boundary Materials. Fusion Materials [7]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. S. Glasstone, A. Sesonske, Von-Nostrand, Nuclear Reactor Engineering, Vol. 1 & 2,
2. J. Kenneth Shultis, Richard E. Faw, Marcel Dekker, Fundamentals of Nuclear Science and Engineering, 2002.
Reference Books:
1. R.L. Murray, Butterworth Heinemann, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 5/e, 2000.
2. A.E. Walter, A.B. Reynolds, Fast Breeder Reactors, Pergamon Press.
3. J.G. Yevick, Fast Reactor Technology, M.I.T, Press.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9020</td><td>Mechanical Behavior and Strong Materials</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To show a fundamental understanding of stress-strain curves.
CO2: To identify various crystal structure imperfections.
CO3: To relate the macroscopic mechanical behavior of materials with the microscopic defects present in them.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: States of stress and strain Transformation of stresses in 2-d; Mohr's circle for stress in 2-d Transformation of stress in 3-d; Mohr’s circle for stress in 3-d Strain; strain deviator; Mohr’s circle for strain Elasticity: origins, isotropic materials, anisotropic material Stress-strain curves; plasticity; empirical relations for stress and strain, criteria for necking, Yield Criteria, Plasticity and the theoretical strength of materials. [15]

Topic 2: Defects in crystalline solids, Slip by dislocation motion and dislocation theory, Implications of dislocation motion and dislocation multiplication, Slip in crystalline solids, Deformation twinning and kink bands, Elastic properties of dislocations, Dislocations in common crystal structures. [13]

Topic 3: Dislocation mobility, stress-strain behavior, and yield point phenomena, Obstacle-based strengthening; introduction to strengthening mechanisms. [8]

Topic 4: Work/strain hardening, Grain size hardening, Solid solution hardening and strain aging, Precipitation hardening, Strain gradient hardening and deformation of multiphase aggregates. [8]

Topic 5: Comments on development of crystalline solids for maximum strength, Fracture, Creep & superplasticity, Fatigue of materials, Martensitic transformations and strengthening, Mechanical behavior of ordered alloys, Mechanical behavior of composite materials, Mechanical behavior of polymeric materials Hardness testing.

[12]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. G.E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 1986.
2. Mechanical Behavior of materials – Thomas H. Courtney

Reference Books:
1. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9021</td><td>Magnetic Properties and Magnetic Materials</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To be able to classify different types of magnetic materials.
• CO2: To be able to apply quantum mechanics to understand the origin of magnetism
• CO3: To be able to explain the molecular origins of higher order magnetic properties such as magnetic anisotropy and domain formation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Classification, Dia, Para, Ferro, Antiferro and Ferrimagnetism, Langevin and Weiss theories. [15]
Topic 2: Quantum theory of diamagnetism, Paramagnetism, Hund rule, Crystal field splitting, Exchange interaction, Magnetic anisotropy, Magnetic domains, Magnetic order [13]
Topic 3: Molecular theory, Hysteresis, Hard and soft magnetic materials, Ferrite structure, Magnons .[13]
Topic 4: Superconductivity, Meissner effect, Type I and Type II superconductors, Heat capacity, London equation and penetration of magnetic field, Cooper pairs and BCS ground state [15]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. P. Robert, Electrical And Magnetic Properties Of Materials, Artech House Publishers, 1988
2. B. D. Cullity, C. D. Graham, Introduction to Magnetic Materials, Wiley
Reference Books:
3. D. Jile, Introduction To Magnetism And Magnetic Materials, Chapman & Hall, 1990</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9022</td><td>Fiber-optic Systems</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To explain propagation of light in optical waveguides.
• CO2: To recall the working principles of optoelectronic devices like optical sources, optical detectors, optical couplers, optical modulators, optical amplifiers, etc.
• CO3: To calculate the loss and dispersion coefficients of optical fibers with various refractive index profiles.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topic 1: Importance of Optical Fiber communication, different types of Fiber, Rays Modes, Step-Index Fiber Structure, Ray optics representation, Wave Representation in a Dielectric Slab Waveguide. [10]

Topic 2: Maxwell’s Equations, Wave Equation for Step-Index Fibers, Modal Equation, Modes in Step-Index Fibers, Linearly Polarized Modes, Power Flow in Step-index Fibers. Single-mode fibers; Mode-Field Diameter, Propagation Modes in Single-Mode Fibers. Graded-Index Fiber Structure. [15]

Topic 3: Attenuation; Absorption, Scattering Losses, Bending Losses, Core and Cladding Losses. Signal distortion in Optical Waveguides; Material Dispersion, Waveguide Dispersion, Signal Distortion in Single-mode Fibers, Polarization-Mode dispersion, Intermodal Distortion. Pulse Broadening in Graded-Index waveguides. [15]

Topic 4: Light Emitting Diodes (LEDs); structure, materials, Quantum Efficiency and LED Power, Modulation of an LED. Laser Diodes; threshold conditions, rate equations, Quantum efficiency, resonant frequencies, structure and radiation patterns, single-mode lasers, modulation, effects of temperature. Optical detector, p-n junction, p-i-n, APD, phototransistor, PMT detectors and other optical devices. [16]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Optical Fiber Communications (3rd Ed.) - Gerd Keiser - McGraw-Hill Int. Editions
2. Fiber Optics and Optoelectronics-R. P. Khare - Oxford University Press
Reference Books:
1. Fiber-Optic Communications Technology- D K. Mynbaev & L Scheiner- Pearson Education
2. Introduction to Fiber Optics, Ajoy Ghatak & K. Thyagarajan – Cambridge University Press</td></tr>
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<table>
<tr><td colspan="9">Department of Physics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td colspan="2" rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>PH9023</td><td>Electron Optics & Microscopy</td><td colspan="2">PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: To differentiate between optical and electron microscopes and explain the advantages of electron microscopy
• CO2: To show an understanding of the operating principles of AFM, STM and TEM microscopies.
• CO3: To outline various characterization techniques using electron microscopy.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Topic 1: Microscopy techniques: Optical microscopy, scanning electron microscopy (SEM), energy dispersive X-ray microanalysis (EDS), transmission electron microscopy (TEM). [14]
Topic 2: Rutherford characterization techniques backscattering spectrometry (RBS). [7]
Topic 3: Atomic force microscopy (AFM) and related scanning probe microscopy (SPM), scanning tunneling microscopy (STM). [15]
Topic 4: Optical characterization techniques: Absorption, transmission, reflection, Fourier transform infrared spectroscopy (FTIR), Photoluminescence, Raman. [12]
Topic 5: X-ray photoelectron spectroscopy (XPS). [8]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:
1. 1. S Zhang, L. Li and Ashok Kumar, Materials Characterization Techniques, CRC Press (2008).
2. 2. D. K. Schroder, Semiconductor Material and Device Characterization, 3rd Edition, Wiley-IEEE Press (2006).

Reference Books:
1. 1. P. E. J. Flewitt and R K Wild, Physical methods for Materials Characterization, IOP Publishing (2003).
2. 2. Characterization of Nanophase materials, Ed. Z L Wang, Willet-VCH (2000).</td></tr>
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