ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. Phil. PHYSICS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

- To provide training in Research Methodology as a pre Ph.D course.
- To provide knowledge in advanced topics in Physics and in particular, Materials Science.
- To provide specialized training and advanced knowledge in the field of interest.
- To provide training in undertaking project work, so as to analyze and solve the problem independently.
- To provide training for making technical presentation and publishing results in any chosen topic related to the field of specialization.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

- The student is motivated and trained to carry out research.
- The student is trained to identify research problem, analyze and interpret data.
- The student gains knowledge in Advanced materials science.
- The student gains knowledge in his/her field of specialization.
- The student is trained to make seminar presentation with confidence.
- The student is trained to communicate effectively and develop leadership qualities.
- The student is trained to deliver the subject concepts with confidence.
- The student is trained to approach and analyze any problem independently.
- The student is trained to prepare project reports and present their work in conferences.
- Students will acquire confidence for self education and ability for life-long learning.

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIOD	L	T	P	C
THEORY								
1.	PX7101	Advanced Materials Science	PC	4	4	0	0	4
2.	PX7102	Research Methodology and Numerical Methods	FC	4	4	0	0	4
3.		Elective I	PE	4	4	0	0	4
4.		Elective II	PE	4	4	0	0	4
			TOTAL	**16**	**16**	**0**	**0**	**16**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIOD	L	T	P	C
THEORY								
1.	PX7211	Seminar	EEC	2	0	0	2	1
2.	PX7212	Project Work	EEC	32	0	0	32	16
			TOTAL	**34**	**0**	**0**	**34**	**17**

TOTAL NUMBER OF CREDITS TO BE EARNED FOR THE AWARD OF DEGREE - 33

FOUNDATION COURSE (FC)								
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIOD**	**L**	**T**	**P**	**C**
1.		Research Methodology and Numerical Methods	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)								
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIOD**	**L**	**T**	**P**	**C**
1.		Advanced Materials Science	PC	4	4	0	0	4

PROFESSIONAL ELECTIVE (PE)								
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIOD**	**L**	**T**	**P**	**C**
1.	PX7001	Advanced Solid State Ionics	PE	4	4	0	0	4
2.	PX7002	Advanced Solid State Theory	PE	4	4	0	0	4
3.	PX7003	Advances in Crystal Growth and Characterization	PE	4	4	0	0	4
4.	PX7004	Chaotronics	PE	4	4	0	0	4
5.	PX7005	Crystal Growth and Structure Determination	PE	4	4	0	0	4
6.	PX7006	Crystal Structure Analysis	PE	4	4	0	0	4
7.	PX7007	Fibre Optics Communications	PE	4	4	0	0	4
8.	PX7008	High Pressure Physics	PE	4	4	0	0	4

9.	PX7009	Introduction to Nanotechnology	PE	4	4	0	0	4
10.	PX7010	Introduction to Nonlinear Optics	PE	4	4	0	0	4
11	PX7011	Introduction to Physical Metallurgy	PE	4	4	0	0	4
12	PX7012	Laser Theory and Applications	PE	4	4	0	0	4
13	PX7013	Materials Characterization	PE	4	4	0	0	4
14	PX7014	Mechanical Behavior of Materials	PE	4	4	0	0	4
15	PX7015	Mechanical Properties of Biological Materials	PE	4	4	0	0	4
16	PX7016	Methods of Characterization of Nanomaterials	PE	4	4	0	0	4
17	PX7017	Modern Alternative Energy Conversion Devices	PE	4	4	0	0	4
18	PX7018	Molecular Biophysics	PE	4	4	0	0	4
19	PX7019	Nonlinear Dynamics of Nanodevices and Systems	PE	4	4	0	0	4
20	PX7020	Nonlinear Science: Solitons and Chaos	PE	4	4	0	0	4
21	PX7021	Solid State Physics	PE	4	4	0	0	4
22	PX7022	Spectroscopic Techniques	PE	4	4	0	0	4
23	PX7023	Superconductiivity and Applications	PE	4	4	0	0	4
24	PX7024	Ultrasonics	PE	4	4	0	0	4

Employability Enhancement Courses (EEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIOD	L	T	P	C
1.		Project Work	EEC	32	0	0	32	16
2.		Seminar	EEC	2	0	0	2	1

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

PX7101 ADVANCED MATERIALS SCIENCE **L T P C**
4 0 0 4

OBJECTIVE

- To impart knowledge on various materials of technological importance

UNIT I SEMICONDUCTING MATERIALS 12

Semiconductor –direct and indirect bonding characteristics – Importance of quantum confinement – Quantum wires and dots – Fabrication process of integrated circuits – Dilute magnetic semiconductors – Characteristics and applications – Ferroelectric semiconductors – Applications - Spintronic Materials and Devices.

UNIT II CERAMIC MATERIALS 12

Ceramic superconductors – Preparation – Sol gel techniques – nanoparticles – Applications – High temperature superconductors – Superconducting magnets – High T_c Tapes – Applications of Composite materials – Fibre reinforced composites – Composite structure and manufacturing methods.

UNIT III POLYMERIC MATERIALS 12

Polymer semiconductors – Photoconductive polymers – Composition and structure of polymers – Electrical conductivity – LEP's design and fabrication – Applications – Mechanical properties – nanoindentation techniques.

UNIT IV OPTICAL MATERIALS 12

Modern imaging materials, Principle of imaging – Superconducting, piezoelectric, acousto-optic and electro-optic materials – Optical storage materials – Photochromic, thermoplastic and Photoresist materials – Materials suitable for detecting toxic gases.

UNIT V NEW MATERIALS 12

Smart materials-Shape memory alloys – Shape memory effect – Martensitic transformation – shape memory alloys – functional properties – processing – texture and its nature - application

TOTAL: 60 PERIODS

OUTCOME

- The students will acquire knowledge on semiconducting materials, ceramic materials, polymeric materials, optical materials and new materials

REFERENCES

1. J.Verdeyen. Laser Electronics, Prentice Hall, 1990.
2. C.W.Turner and T.Van Duzer. Principles of Superconductive Devices and Circuits, 1981
3. Reynolds and M.Pomeranty in Electroresponsive molecules and polymeric systems Ed. by Skotheim T. Marcel Dekker, New York, 1991.
4. A.Yariv. Principles of Optical Electronics, John Wiley, New York, 1984
5. B.Hull and V.John. Non-Destructive Testing, McMillan Education Ltd., London, 1988.
6. H.Funakubo. Shape memory alloys .Gordon & Breach, New York, 1984.

PX7102 RESEARCH METHODOLOGY AND NUMERICAL METHODS **L T P C**
4 0 0 4

OBJECTIVE

- To expose the student with various mathematical methods for numerical analysis and use of computation tools

UNIT I RESEARCH METHODOLOGY 12

Introduction - Defining research problem - research design - Important concepts - different research design - basic principles of experimental design - sampling design - steps and types of sampling design. Purpose and problem statements - Literature review - Frameworks - Research questions and hypotheses - Multimethod research.

UNIT II NUMERICAL INTERPOLATION, DIFFERENTIATION AND INTEGRATION 12

Newton's forward and backward interpolation formulae - Lagrange's interpolation formula for unequal intervals - Error in polynomial interpolation and Newton's interpolation formula - Numerical differentiation - Maximum and minimum of a tabulated function - Numerical integration - Trapezoidal rule - Romberg's method- Simpson's rule - Practical applications of Simpson's rule.

UNIT III NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 12

Solution by Taylor's series - Euler's method - Runge-Kutta method - Predictor - Corrector method - Milne's method - Adam Baschforth method - Numerical solution of partial differential equations - Finite equations - Elliptic equations - Laplace equation - Poisson's equation - Parabolic equations - Hyperbolic equations.

UNIT IV EMPRICAL LAWS AND CURVE FITTING 12

Linear law and laws reducible to linear law - Graphical method - method of group averages - principle of least squares - Fitting of straight line and parabola.

UNIT V C - PROGRAMMING 12

Variables, constants, strings - Arrays - arithmetic operations and statements - shorthand assignment - input and output statements (scanf, printf) - format specifications - relational operators - local expressions and operators - if / else, for, while loops - functions (library and user-defined) - simple programs using standard numerical methods from the above chapters (four different programs at least from each chapter).

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on systems of equation, probability statistics and error analysis and programming concepts.

REFERENCES

1. C.RKothari. Research Methodology. New Age International publishers, New Delhi, 2008
2. E.Balagurusamy. Programming in ANSI C. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
3. S.S.Shastry. Introductory methods of numerical analysis. Prentice Hall, New Delhi, 1984

PX7001	ADVANCED SOLID STATE IONICS	L	T	P	C
		4	0	0	4

OBJECTIVE

- To expose the students with theoretical aspects of advanced solid state ionics and their applications

UNIT I INTRODUCTION 12

Bonding types in solids - Fundamentals of Crystallography - Simple Crystal structures - X-ray crystal diffraction - bond structures of metals, semiconductors and insulators - Ionic and electronic conductivities.

UNIT II SUPERIONIC MATERIALS AND STRUCTURES 12

Types of ionic solids - Superionic materials - Alkali metal ion conductors - silver ion conductors - Copper ion conductors - structural: principles for high silver and copper ion conductors - proton conductors - electronic conductors with ion transport - Hydrogen storage materials.

UNIT III EXPERIMENTAL PROBES 12

Structural characterization - Thermodynamic properties - ion transport (macroscopic properties) - Ion dybnamics (microscopic properties) - Phoelectron spectroscopy - EXAFS (extended X-ray absorption fine structure) - Local environment studies - FTIR, Thermal analysis - DTA - DSC - TG. - Particle size analysis - SEM-TEM.

UNIT IV APPLICATION OF SUPER IONIC SOLIDS 12

Diffusion coefficient measurement in solids/liquids-sensor and partial pressure gauges - oxygen sensors (concentration cell type) - sulfur sensor (formation cell type) - Fuel cells - solid state battery - super capacitors.

UNIT V LITHIUM BATTERIES 12

Principles and general background of ambient temperature lithium batteries - synthesis of nano materials for lithium batteries - properties, structure and conductivity of organic and inorganic electrolytes for lithium battery systems - thin film deposition - pulsed laser deposition of electrodes - preparation and fabrication - characterization of Li-ion cells - Comparison of lead acid-NiCd and Li-ion batteries - Application of Lithium batteries in electronic devices and electric vehicle - Solar energy conversion devices.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on fundamentals of solid state physics, superionic materials and structures, experimental probes, applications of superionic solids and lithium batteries.

REFERENCES

1. S.Chandra. Superionic solids:Principles and applications. North Holland Amsterdam, 1981.
2. H.V.Keer. Principles of solid state physics. Wiley Eastern Ltd., New Delhi, 1993.
3. D.S.Clive. Modern Battery Technology. Alean International Ltd, Banbury, Elis Horwood Publishers, 1991.
4. J.P.Gabano. Lithium batteries. Academic Press, London, 1983.
5. S.Selladurai. (Ed.). Solid State Ionic Device: Science & Technology. Allied Publishers, Chennai, 2000.
6. G.A.Ozin and C.Arsenault Andre. Nanochemistry, A chemical approach to nanomaterials. Springer, 2005.

PX7002	ADVANCED SOLID STATE THEORY	L	T	P	C
		4	0	0	4

OBJECTIVE:

- To expose the students with theoretical aspects of solid state theory

UNIT I ATOMIC MOLECULAR STRUCTURE 12

Central field approximation - Thomas Fermi model and its application - Hartree and Hartree Fock equations - hydrogen molecule - Heitler London model - hybridization.

UNIT II DENSITY FUNCTIONAL THEORY 12

Hohenberg-Kohn theorem - Kohn-Sham ansatz - approach to many-body problem using independent particle methods - solving Kohn-Sham equations - LDA - LSDA - GGA - nonlocal functionals.

UNIT III BAND STRUCTURE METHODS 12

The tight-binding method - linear combination of atomic orbitals - application to bands from *s*-levels general features of tight-binding levels - Wannier functions

UNIT IV OTHER BAND STRUCTURE METHODS 12

Independent electron approximation - general features of valence band wave functions - cellular method - muffin-tin potentials - augmented palne wave method - Green's function (KKR) method - orthogonalized plane wave method - pseudopotentials.

UNIT V PREDICTING PROPERTIES OF MATTER FROM ELECTRONIC STRUCTURE 12

Lattice dynamics from electronic structure theory - phonons and density response functions - periodic perturbations and phonon dispersive curves - dielectric response functions - effective charges - electron-phonon interactions and superconductivity - magnons and spin response functions.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on band theory and band structure methods.

REFERENCES

1. Richard M.Martin. Electronic structure Basic theory and prtical methods. Cambridge University press, 2004
2. N.W. Ashcroft and N.D.Mermin, Solid State Physics. Saunders, 1976.
3. H.L.Skriver, The LMTO method. Springier, Berlin, 1984.
4. G.C.Fletcher. Electron theory of solids. North Holland Pub. Co. 1980.

PX7003	ADVANCES IN CRYSTAL GROWTH AND CHARACTERISATION	L T P C
		4 0 0 4

OBJECTIVE

- To introduce the knowledge on crystal growth and characterization.

UNIT I NUCLEATION 12

Theory of nucleation – Gibbs-Thomson equation for vapour, melt and solution – energy of formation of a nucleus – different possible shapes of nucleus – Homogeneous nucleation of Binary system – Heterogeneous nucleation – cap shaped – disc shaped nucleus.

UNIT II CRYSTAL GROWTH THEORY 12

Surface energy theory – Diffusion theory – Adsorption layer theory – Volm1er theory – Bravais theory – Kossel theory – Stranski's treatment. Bulk diffusion model – Physical modelling of BCF theory – BCF differential surface diffusion equation – Temkins model of crystal growth, PBC theory of crystal growth.

UNIT III BULK CRYSTAL GROWTH 12

Bridgman technique – Czochralski technique – Growth of III – V materials – Liquid Encapsulated Czochralski technique (LEC) – Growth of oxide materials – Solution growth – Low temperature solution growth – High temperature solution growth (flux growth), Hydrothermal method.

UNIT IV CRYSTAL GROWTH – FILMS AND EPITAXIAL LAYERS 12

Electrocrystallization – Liquid Phase Epitaxy (LPE) – Vapour Phase Epitaxy – Metal Organic Vapour Phase Epitaxy (MOVPE) – Molecular Beam Epitaxy (MBE) – Atomic Layer Epitaxy (ALE) – Chemical Beam Epitaxy (CBE).

UNIT V CHARACTERIZATION TECHNIQUES 12

Single crystal diffraction techniques – Powder diffraction – X- ray fluorescence - Electron Probe Micro Analysis – Secondary Ion Mass Spectroscopy (SIMS), Electron Spectroscopy for Chemical Analysis (ESCA)- Electrical conductivity – Measurement of dielectric constant – Microhardness – Etching studies.

TOTAL: 60 PERIODS

OUTCOME

- The students will understand the theories of nucleation and crystal growth, crystal growth from solution, melt and vapour phase and their characterization.

REFERENCES

1. Makoto Ohara and Robert C. Reid., Modelling crystal growth rates from solution. Prentice-Hall of India P.Ltd, New Delhi, 1973.
2. J.C. Brice, Crystal Growth Processes .John Wiley & Sons, New York, 1986.
3. B.R. Pamplin. Crystal Growth. Pergamon press, London, 1975.
4. X.F. Zong, Y.Y. Wang, Material and Process Characterization for VLSI J. Chen, World Scientific, New Jersey,1988.
5. Krishan Lal. Synthesis, Crystal Growth & Characterization. North-Holland, Amsterdam, 1982.
6. M.M.Faktor and I. Garret. Growth of crystals from vapour Chapman and Hall, London, 1974.
7. Siblia J.P. A guide to Materials Characterisation and chemical Analysis. VCH Publications, 1988.
8. P.Santhana Raghavan and P.Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam, 2000.

PX7004	**CHAOTRONICS**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

OBJECTIVE

- To prepare the students to understand the concepts of chaos in electronic circuits

UNIT I LINEAR AND NONLINEAR CIRCUITS 12

Linear circuit elements – nonlinear circuit elements – circuits with linear elements – circuits with nonlinear elements – LC, RLC and forced RLC circuits - importance of nonlinearity – low and higher order electronic circuits with nonlinearity – Op-amp: Mathematical operations.

UNIT II BIFURCATION AND CHAOS 12

Introduction – periodic, quasi-periodic and chaotic behaviours – types of bifurcations – routes to chaos– discrete and continuous dynamical systems – characterization of periodic and chaotic motions.

UNIT III DISCRETE MAP BASED CHAOTIC CIRCUITS 12

Introduction – logistic map dynamics – circuit realization of logistic map – cob-web diagrams – Poincare-map construction - bifurcation diagram circuits – Henon map circuit – phase-portrait.

UNIT IV CONTINUOUS TYPE CHAOTIC CIRCUITS 12

Introduction – autonomous chaotic circuits: Chua's diode, Chua's circuit, Chua's canonical circuit – Wien-bridge oscillator based chaotic circuit – Colpitts chaotic oscillator – negative resistance based chaotic circuits – LC oscillator based chaotic circuits. Non-autonomous chaotic circuits: RL-diode circuit, driven Chua's circuit - Murali-Lakshmanan-Chua (MLC) circuit, Lindberg-Murali-Tamasevicius (LMT) oscillator – stochastic resonance circuit. Analog simulation circuits: Duffing oscillator, van-der Pol oscillator – Lorenz system – Rossler system – Threshold-controller based circuits.

UNIT V HIGHER-ORDER CHAOTIC CIRCUITS 12

Introduction – simple hyper-chaotic circuits with LCR elements – negative resistance based hyper-chaotic circuits – delay-chaotic circuits: autonomous and non-autonomous versions. Power-electronic circuits – CNN based chaotic circuits.

TOTAL: 60 PERIODS

OUTCOME

- The students will understand the concepts of chaos phenomena and experimental realization of different types of chaotic electronic circuits.

REFERENCES

1. M. Lakshmanan and K. Murali. Chaotic oscillators: Controlling and synchronization. World Scientific, Singapore, 1996.
2. M. Lakshmanan and S. Rajasekar. Nonlinear dynamics: Integrability, chaos and patterns. Springer, Berlin, 2001.
3. S.H.Strogatz. Nonlinear dynamics and chaos. Addison-Wesley, Manchester, 1994.
4. L.O. Chua, C.A. Desoer and E.S. Kuh. Linear and nonlinear circuits. McGraw-Hill, Singapore 1987.
5. L.O.Chua. CNN: A paradigm for complexity. World Scientific, Singapore, 1998.
6. M.A. van Wyk and W.H. Steeb. Chaos in electronics. Springer, Berlin, 1997.

PX7005	**CRYSTAL GROWTH AND STRUCTURE DETERMINATION**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

OBJECTIVE

- To provide knowledge on crystal growth and structure determination

UNIT I NUCLEATION CONCEPT 12

Kinds of nucleation - Homogeneous nucleation – Heterogeneous nucleation - - Energy of formation of a critical nucleus - Theories of crystal growth - Two dimensional nucleation theory - thermodynamics of nucleation - Free energy of formation of a two dimensional nucleus - Rate of nucleation - Mononuclear model - Polynuclear model - Birth and spread model - Modified Birth and spread model - Physical modeling of BCF theory - BCF differential surface diffusion equation - single straight step - Temkins model of crystal growth.

UNIT II GROWTH OF CRYSTAL FROM MELT 12

Bridgman method - Kyropolous method - Czochralski method - Verneuil method - Zone melting method

UNIT III GROWTH OF CRYSTALS FROM VAPOUR PHASE 12

Physical vapour deposition - Chemical vapour transport - Open and closed system - Growth of crystals from solutions - solvents and solutions - solubility - preparation of a solution - Saturation and supersaturation - Low temperature solution growth - Slow cooling method Mason-jar method - Evaporation method - Temperature gradient method - Electro crystallization - Crystal growth in gels - Experimental methods - Chemical reaction method - Reduction method - Crystal growth by hydrothermal method.

UNIT IV SYMMETRY LATTICE 12

Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements, operations - translational symmetries - point groups - space groups - equivalent positions - Bragg's law – reciprocal lattice concept - Laue conditions - Ewald and limiting spheres - diffraction symmetry - Laue groups.

UNIT V STRUCTURE DETERMINATION 12

X-ray diffraction - Powder method - rotating crystal method - specimen preparation- measurement of d-values - indexing procedure for crystals - Single crystal diffractometer- - four crystal diffractometer - double crystal diffractometer -determination of unit cell and space group. - X-ratopography(XRT) - Neutron diffraction

TOTAL : 60 PERIODS

OUTCOME

- The students will gain knowledge on nucleation theory, various techniques of crystal growth, symmetry lattice and structure determination.

REFERENCES

1. M.Ohara and R.C.Reid. Modelling crystal growth rates from solution. Prentice-Hall of India Pvt. Ltd., New Delhi, 1973.
2. J.C.Brice. Crystal growth processes. John Wiley & Sons, New York, 1986.
3. B.R.Pamplin, Crystal Growth. Pergamon Press, London, 1975.
4. X.F. Zong, Y.Y. Wang and J. Chen. Material and Process Characterization for VLSI. World Scientific, New Jersey, 1988.
5. Krishan Lal. Synthesis, Crystal Growth & Characterization. North-Holland, Amsterdam, 1982.
6. A.A.Chernov. Modern crystallography - Vol. III. Nauka Publishing House, Moscow,1980.
7. P.Hartman (Ed.). Crystal Growth - An introduction. North-Holland Publication Co. Amsterdam, 1972.
8. L.A.Azarof. X-ray diffraction. McGraw Hill Book Company, 1974.
9. L.V.Azarof. Elements of X-ray Crystallography. McGraw-Hill Book Company, 1968.

PX7006 CRYSTAL STRUCTURE ANALYSIS **L T P C**
4 0 0 4

OBJECTIVE

- To teach the students about the concepts of crystal structure analysis

UNIT I SYMMETRY: LATTICE 12

Unit cell and Bravais lattices - crystal planes and directions - basic symmetry elements operations - translational symmetries - point groups - space groups - equivalent positions - Bragg's law - reciprocal lattice concept -Laue conditions - Ewald and limiting spheres diffraction symmetry - Laue groups.

UNIT II DIFFRACTION 12

X-ray generation, properties - sealed tube, rotating anode, synchrotron radiation - absorption - filters and monochromators Atomic scattering factor - Fourier transformation and structure factor - anomalous dispersion - Laue, rotation/oscillation, moving film methods - interpretation of diffraction patterns - cell parameter determination - systematic absences - space group determination.

UNIT III STRUCTURE ANALYSIS 12

Single crystal diffractometers - geometries - scan modes - scintillation and area detectors - intensity data collection - data reduction - factors affecting X-ray intensities - temperature and scale factor - electron density - phase problem - normalised structure factor - direct method fundamentals and procedures -Patterson function and heavy atom method - structure refinement - least squares method - Fourier and difference Fourier synthesis - R factor - structure interpretation - geometric calculations - conformational studies - computer program packages.

UNIT IV POWDER METHODS 12

Fundamentals of powder diffraction - Debye Scherrer method - diffractometer geometries - use of monochromators and Soller silts - sample preparation and data collection - identification of unknowns - powder diffraction files (ICDD) - Rietveld refinement fundamentals - profile analysis - peak shapes - whole pattern fitting - structure refinement procedures - autoindexing - structure determination from powder data - new developments. Energy dispersive X-ray analysis - texture studies - crystallite size determination - residual stress analysis - high and low temperature and high pressure crystallography (basics only).

UNIT V PROTEIN CRYSTALLOGRAPHY 12

Globular and fibrous proteins, nucleic acids - primary, secondary, tertiary and quaternary structures - helical and sheet structures - Ramachandran map and its significance - crystallation methods for proteins - factors affecting protein crystallisation - heavy atom derivatives - methods used to solve protein structures - anomalous dispersion methods.

TOTAL: 60 PERIODS

REFERENCES

1. Azaroff, L.V., "Elements of X-Ray Crystallography", Techbooksl, New York, 1992.
2. Blundell, T.L. and Johnson, L., "Protein Crystallography", Academic Press, New York, 1986.
3. Cullity, B.D. and Stock,S.R. "Elements of X-ray Diffraction", Pearson, 2014
4. Glusker, J.P. and Trueblood, K.N. Crystal Structure Analysis: A Primer", Oxford University Press, New York, 1994.
5. Ladd, M.F.C. and Palmer, R.A., "Structure Determination by X-ray Crystallography", Plenum Press, New York, 3rd Edition, 1993.
6. Stout, G.H. and Jensen, L."X-ray Structure Determination, A Practical Guide", Macmillan : New York, 1989.
7. Woolfson, M.M. "An Introduction to X-ray Crystallography" Cambridge University Press, New York, 1997.

PX7007 FIBRE OPTICS COMMUNICATIONS

L	T	P	C
4	0	0	4

OBJECTIVE

- To make the students understand the concepts of fibre optics communications

UNIT I INTRODUCTION TO OPTICAL COMMUNICATION 12

Principles of light transmission in fibers - optical fiber modes and configuration - Mode theory for circular wave guides, single mode fibers, Multi – mode fibers, Numerical Aperture, Mode Field Diameter, V-Number - Optical power, polarization, bandwidth and signal quality measurements - Advance fiber design: Dispersion shifted, Dispersion flattened, Dispersion compensating fiber, Design optimization of single mode fibers. Advantages and disadvantages of the optical communication systems.

UNIT II INSTRUMENTS 12

Optical sources - LEDs, LASER Diodes, Modal Reflection Noise, Power Launching & Coupling, Fiber splicing, optical connectors, photo detectors - PIN, Avalanche Detectors - Response Time, Avalanche Multiplication Noise - Optical Amplifiers – EDFA, semiconductor and Raman amplifiers.

UNIT III SIGNAL PROPAGATION 12

Signal Degradation in optical fibers - Attenuation losses - signal distortion in optical wave guides - material dispersion - wave guide dispersion - chromatic dispersion - Intermodal dispersion - pulse broadening in graded-index fibers - mode coupling - Coherent optical fiber communication - Modulation Techniques - Line Coding: NRZ, RZ, Block codes, Error correction.

UNIT IV OPTICAL NETWORKS AND WDM CONCEPTS 12

Optical networks- Basic networks-sonnet/ SDH-wavelength routed networks - Global networks – joining networks, terrestrial and long-distance systems - Regional networks – design of regional and metropolitan networks - Local networks – emerging services, passive networks, Gigabit Ethernet and Internet protocols, computer and phone networks – Principle of WDM – Passive Components – Couplers- Multiplexing and De-multiplexing – Tunable sources – Phase array based WDM Devices.

UNIT V DISPERSION COMPENSATION AND SOLITONS 12

Limitations, Post-and Pre-compensation techniques, Equalizing filters, fiber based gratings, Broad band compensation - Nonlinear effects in fiber optic links. Concept of self-phase modulation, group velocity dispersion and solition based communication systems - design, High capacity and WDM soliton system – Dispersion –managed Solitons.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the basics fibre optical communication, instruments, signal propagation, optical networks & WDM concepts and dispersion compensation and solitons.

REFERENCES

1. J.Keiser, Fibre Optic communication, McGraw-Hill, 2nd Ed. 1992.
2. J.E. Midwinter, Optical fibers for transmission, John Wiley, 1979.
3. J.Gowar, Optical communication systems, Prentice Hall India, 1987
4. G. P. Agrawal, Nonlinear fibre optics, Academic Press, 2005.

PX7008 HIGH PRESSURE PHYSICS L T P C
4 0 0 4

OBJECTIVE

- To introduce the knowledge on high pressure physics

UNIT I GENERAL TECHNIQUES 12

Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder – Bridgmann Anvil – Multi anvil devices – Diamond anvil cell. Measurement of High Pressure Primary gauge – Secondary gauge – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.

UNIT II HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS 12

X – Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies – High and low temperature applications – Ultra high pressure anvil devices.

UNIT III HIGH PRESSURE PHYSICAL AND CHEMICAL PROPERTIES 12

PVT Relations in fluids – Properties of gases under pressure – Melting phenomena – viscosity – thermo emf – thermal conductivity. Electrical conductivity – phase transition phonons, superconductivity – Electronic structures of metals and semiconductors – NMR and magnetic properties. Liquid crystals – spectroscopic studies – Infra red, Raman, Optical absorption – EXAFS.

UNIT IV MECHANICAL PROPERTIES AND INDUSTRIAL APPLICATIONS 12

Elastic constants – Measurements – Mechanical properties – Tension and compression – Fatigue – creep – Hydrostatic extrution, material synthesis – superhard materials – Diamond – oxides and other compounds – water jet.

UNIT V DYNAMIC PRESSURES 12

Shock wave – generation – measurements - Effect of shock wave on metals – Applications of shock wave.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the general techniques of producing high pressure and their measurement, high pressure devices, high pressure physical, chemical mechanical properties & industrial applications and concept of dynamic pressures.

REFERENCES
1. W. Bridgmann, The Physics of High Pressure, G. Bell and Sons Ltd., London, 1931.
2. B Vodar and Ph. Marteam, High Pressure Science and Technology, Vol I and II Pergamon Press, Oxford, 1980.
3. H.LI. D. Pugh, Mechanical Behaviour of Materials under Pressure,Elsevier Publishing Co., Ltd., New York, 1970.
4. M. I. Eremets, High Pressure Experimental methods, Oxford University press, New York, 1976.

PX7009 INTRODUCTION TO NANOTECHNOLOGY

L	T	P	C
4	0	0	4

OBJECTIVE
- To introduce knowledge on basics of Nanotechnology and importance of Nanotechnology

UNIT I NANO SYSTEMS 12

Size effect and properties of nanoparticles - particle size - particle shape - particle density - melting point, surface tension, wettability - specific surface area and pore size – Reason for change in optical properties, electrical properties, and mechanical properties. Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures- Top down and Bottom up approach.

UNIT II SYNTHESIS OF NANOMATERIALS 12

Gas phase condensation – Vacuum deposition -Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablation- Sol-Gel- Ball milling –Electro deposition- electro less deposition – spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis

UNIT III NANOTUBES 12

Single walled and Multi walled Nanotubes (SWNT and MWNT) - synthesis and purification - synthesis of carbon Nanotubes by pyrolysis techniques - arc-discharge method - nanotube properties – Nanowires – methods of preparation of nanowires –VLS mechanism

UNIT IV CHARACTERIZATION 12

Principle and working of Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - near-field Scanning Optical Microscopy – Principle of Transmission Electron Microscopy (TEM) – applications to nanostructures – nanomechanical characterization – nanoindentation

UNIT V NANOTECHNOLOGY APPLICATIONS 12

Applications of nanoparticles, quantum dots, Nanotubes and nanowires for nanodevice fabrication – Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs – CNT based transistors – principle of Dip Pen Lithography.

TOTAL: 60 PERIODS

OUTCOME
- The students will gain knowledge on the fundamental aspects leading to nantechnology

REFERENCES
1. G.Timp. (Ed.). Nanotechnology. AIP press, Springer-Verlag, New York, 1999
2. Hari Singh Nalwa (Ed.). Nanostructured materials and Nanotechnology. Academic Press, USA, 2002.
3. Hari Singh Nalwa (Ed.). Hand book of Nanostructured Materials and Technology. Vol.1-5, Academic Press, USA , 2000.
4. Hand book of Nanoscience, Engineering and Technology (The Electrical Engineering handbook series). Kluwer Publishers, 2002
5. N John Dinardo. Nanoscale characterization of surfaces & interfaces. Weinheim Cambridge: Wiley-VCH, 2000.

PX7010 INTRODUCTION TO NONLINEAR OPTICS

	L	T	P	C
	4	0	0	4

OBJECTIVE

- To enlighten the students with the concepts of nonlinear optics.

UNIT I ORIGIN OF OPTICAL NONLINEARITIES 12

Effects due to quadratic and cubic polarization – Response functions – Susceptibility tensors – Linear, second order and n^{th} order susceptibilities – Wave propagation in isotropic and crystalline media – The index ellipsoid.

UNIT II SECOND HARMONIC GENERATION (SHG) AND PARAMETRIC OSCILLATION 12

Optical SHG – Phase Matching – Experimental verification – Parametric oscillation – Frequency tuning– Power output and pump saturation – Frequency up conversion – Materials.

UNIT III THIRD ORDER NONLINEARITIES 12

Intensity dependent refractive index – Nonlinearities due to molecular orientation – Self-focusing of light and other self-action effects - Optical phase conjugation – Optical bistability and switching- Pulse propagation and temporal solitons.

UNIT IV ELECTRO –OPTIC AND PHOTOREFRACTIVE EFFECTS 12

Electro- optic effects – Electro-optic modulators - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

UNIT V STIMULATED SCATTERING PROCESSES 12

Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the concepts of origin of optical nonlinearities, second harmonic generation & parametric oscillation, third order nonlinearities, electrooptic and photo refractive effects and stimulated scattering process.

REFERENCES

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 1992. (Units II and IV)
2. A.Yariv, Opto Electronics, Third Edition, John Wiley and Sons, New York, 1990. (Unit II)
3. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, Cambridge Univ. Press, New York, 1990. (Unit I & V)
4. Y.V.G.S.Murti and C.Vijayan. Essentials of Nonlinear Optics. Wiley (2014).

PX7011 INTRODUCTION TO PHYSICAL METALLURGY

	L	T	P	C
	4	0	0	4

OBJECTIVE:

- To teach the students about the basic concepts of physical metallurgy

UNIT I STRUCTURE OF ALLOYS 12

Hume Rothery rules - Intermediate phases – Intermetallic compounds – Improvement in mechanical and electrical properties – metallography: Optical microscope – SEM – TEM – Determination of chemical composition – Electron probe microanalysis.-Structural stability of alloys-EXAFS measurements.

UNIT II PHASE DIAGRAMS 12

Free energy – Composition curves – Lever rule – Invariant reactions – Eutectic system – Property variations in eutectic systems –Peritectic and peritectoid systems- Non equilibrium solidification – Zone meting.

UNIT III DIFFUSION 12

Ficks laws – Mechanisms of diffusion – Solutions of diffusion equation – Kirkendal effect – Factors affecting diffusion – Applications of diffusion.

UNIT IV MECHANICAL PROPERTIES 12

Stress-strain curve – Compressibility – Plastic deformation mechanisms, Tensile strength – Creep – Fracture – Fatigue failures – Effect of grain size on mechanical properties-Hardness.

UNIT V ENGINEERING ALLOYS 12

Steels – High strength structural steels – tool materials – high temperature alloys – cast iron – light alloys – Al, Mg and Ti and their alloys – Copper based systems –brass and bronze.

TOTAL : 60 PERIODS

OUTCOME

- The students will understand the concepts of structure of alloys, phase diagrams, diffusion, mechanical properties and engineering alloys.

REFERENCES

1. A.G.Guy and J.J.Hren. Physical Metallurgy, Oxford, IBH, 1980.
2. Raghavan.V., Physical Metallurgy, Prentice Hall, 1989.
3 .Westbrook.J. (Ed.), Intermetallics, Academic Verlag, 1995.
4. Taylor. X-ray metallography, Mentice Hall, 1982.

PX7012 LASER THEORY AND APPLICATIONS

L	T	P	C
4	0	0	4

OBJECTIVE:

- To expose the students with theoretical aspects of laser theory and its applications.

UNIT I LASER THEORY 12

Absorption - Spontaneous and stimulated emission - Einstein's coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems.

UNIT II RESONATORS AND SWITCHING THEORY 12

Resonant cavity - Fox and Li - Boyd and Gorden's theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

UNIT III GAS AND LIQUID LASERS 12

He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers organic dyes - Pulsed and CW dye lasers - Threshold conditions - Puming configurations.

UNIT IV SOLID STATE AND SEMICONDUCTOR LASERS 12

Ruby, Nd: YAG, Nd: Glass, Ti-sapphire, Alexandrite, lasers - Semiconductor lasers - Homo function - Hetro function - Quantum well laser.

UNIT V APPLICATIONS **12**

Speckle, speckle interferometry - Holography - Holographic interferometry - Material processing - Surface treatment - welding, drilling - Laser ranging - Laser Doppler Velocimetry - Pollution monitoring - Medical applications.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on laser theory, resonators and switching theory, gas & liquid lasers, solid state & semiconductor lasers and their applications.

REFERENCES

1. William T. Silfvast. Laser Fundamentals. Cambridge University Press, 1999.
2. Oshea, Callen and Rhcdes. An Introduction to Lasers and their Applications. Addison Wesley, 1985.
3. A.Yariv. Quantum Electronics. Addison-Wesley, 1990.
4. Hariharan. Optical Holography. Academic Press, New York, 1983.
5. R.K.Erf.. Speckle Metrology. Academic Press, New York, 1978.

PX7013	**MATERIALS CHARACTERIZATON**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

OBJECTIVE

- To introduce various methods available for characterizing the materials

UNIT I THERMAL ANALYSIS **12**

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

UNIT II MICROSCOPIC METHODS **12**

Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy - phase contrast microscopy -differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - - digital holographic microscopy - oil immersion objectives - quantitative metallography - image analyzer.

UNIT III ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY **12**

SEM, EDAX, EPMA, TEM: working principle and Instrumentation – sample preparation – data collection, processing and analysis- Scanning tunneling microscopy(STEM)- Atomic force microscopy(AFM) - Scanning new field optical microscopy

UNIT IV ELECTRICAL METHODS AND OPTICAL CHARACTERISATION **12**

Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations. Photoluminescence – light – matter interaction – instrumentation – electroluminescence – instrumentation – Applications.

UNIT V X-RAY AND SPECTROSCOPIC METHODS **12**

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR,NQR, XPS, AES and SIMS-proton induced X-ray Emission spectroscopy (PIXE) – Rutherford Back Scattering (RBS) analysis-application - Powder diffraction - Powder diffractormeter - interpretation of diffraction patterns - indexing - phase identification - residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - uses.

TOTAL: 60 PERIODS

OUTCOME

- The students will understand the thermal, microscopic, electrical and spectroscopic methods of characterization.

REFERENCES

1. R.A.Stradling and P.C.Klipstain. Growth and Characterization of semiconductors. Adam Hilger, Bristol, 1990.
2. J.A.Belk. Electron microscopy and microanalysis of crystalline materials. Applied Science Publishers, London, 1979.
3. Lawrence E.Murr. Electron and Ion microscopy and Microanalysis principles and Applications. Marcel Dekker Inc., New York, 1991
4. D.Kealey and P.J.Haines. Analytical Chemistry. Viva Books Private Limited, New Delhi, 2002.

PX7014 MECHANICAL BEHAVIOR OF MATERIALS

L	T	P	C
4	0	0	4

OBJECTIVE:

- To introduce knowledge on basics of nanoindentation and the importance of nanoindentation

UNIT I MECHANICAL PROPERTIES OF BULK MATERIALS 12

Mechanical properties of inorganic materials (metals, ceramics) and organic materials (polymers, fibres) and composites (material blends, nanocomposites, filled and reinforced systems). Mechanical testing, enthalpy elasticity, rubber elasticity, viscoelasticity, plasticity, viscoplasticity, fracture properties, deformation velocity and temperature influence. Molecular and morphological influence on the mechanical properties. External influence including moisture, solvents and oxidation. Introduction to the mechanical behavior of small scale components, structures and devices.

UNIT II MECHANICAL PROPERTIES OF THIN FILMS 12

Stresses in thin films -Measurement of stresses in thin films -Wafer curvature and Stoney equation - Stresses due to different deposition processes.

UNIT III MECHANICAL PROPERTIES OF BIOMATERIALS 12

Introduction to nanomechanics - Force versus distance curve - Single cell mechanics Qualitative introduction to intra - and intermolecular forces - Quantitative description of intra - and intermolecular forces - Molecule - surface interactions - Colloids and interparticle potentials - Van der Waals forces at work: Gecko feet adhesion - The electrical double layer (EDL) theory - Nanomechanics of cartilage - Protein - surface interactions - Nanomechanics and biocompatibility: Protein-biomaterial interactions -

UNIT IV MECHANICAL PROPERTIES OF NANOMATERIALS 12

Deformation behaviour of nanomaterials. – comparison of mechanical characterics in bulk and nano – Reason for change in characteristics - Fracture and creep - Nanomechanics and nanotribology.

UNIT V INSTRUMENTS FOR MEASUREMENT 12

Small scale mechanical characterization including: nanoindentation, thin film bulge test, and electron microscopy methods. Nanoindentation: Force control and displacement control – common sources of artifacts – Nanoindentation instrumentation - Atomistic theories of tip-sample interaction- Oliver-Pharr method – other techniques of Nanoindentation – Different types of Nanoindentation.

TOTAL: 60 PERIODS

Attested

OUTCOME

- The students will gain knowledge on the nanoindentation testing methods in bulk nanomaterials and biological materials.

REFERENCES

1. Nanoindentation, Anthony C. Fischer-Cripp, Springer-Verlag GmbH, 2002
2. Nanoindentation in Materials Science, Edited by Jiri Nemecek, ISBN 978-953-51-0802-3, InTech publishers, 2012
3. Nanoindentation, 3rd Edition Fischer-Cripps Laboratories Pty Ltd.
4. Fundamentals of Nanoindentation and Nanotribology, Norbert Hubert (Editor), Materials Research Society, 2009, ISBN-10: 155899789X
5. Fundamentals of Nanoindentation and Nanotribology, Kathryn J, Materials Research Society, 2004
6. Nanoindentation in Materials Science" ed by Jiří Němeček, Publishers InTeOp, 2012, ISBN: 9535108023 9789535108023

PX7015 MECHANICAL PROPERTIES OF BIOLOGICAL MATERIALS **L T P C**
4 0 0 4

OBJECTIVE:

- To introduce knowledge on basics of Nanoindentation and the importance of Nanoindentation

UNIT I PREVIEW OF MECHANICS OF THE MUSCULOSKELETAL SYSTEM 12

Kinematics and kinetics of the musculoskeletal system, forces, stress and strain. - Review of continuum mechanics - Review of continuum mechanics II: vector and tensor algebra - Nano- and ultrastructure of biological tissues and tissue components –

UNIT II NANOMECHANICS OF BIOLOGICAL TISSUE COMPONENTS 12

Entropic elasticity - Mechanics of the musculoskeletal system - Bone I: Material properties, mechanical analysis and characterization of bone tissue - Mechanics of the musculoskeletal system - Bone -Modelling, remodelling, fracture mechanics, pathological degeneration and repair of bone Tissue

UNIT III SOFT TISSUE MECHANICS 12

Non-linear continuum mechanics – Kinematics, strain and strain rate measures Soft tissue mechanics II: Non-linear continuum mechanics, stress and stress rate measures - Soft tissue mechanics III: Constitutive modelling of soft biological tissues – Isotropic and anisotropic hyperelasticity (ligaments/tendons) - Soft tissue mechanics IV: Constitutive modelling of soft biological tissues – Viscoelasticity (hysteresis, stress relaxation, creep, strain rate-dependence, rheological models) (tendons/ligaments), Biot's theory of poroelasticity (cartilage).

UNIT IV MECHANICS OF THE MUSCULOSKELETAL SYSTEM 12

Cartilage: Material properties, mechanical analysis and characterization of cartilage - Material properties, mechanical analysis and characterization of tendon and ligaments - Various topics of Mechanical properties of biological materials –Skin: Material properties, mechanical analysis and characterization of skin - Muscle: Material properties, mechanical analysis and characterization of muscle - Arteries: Material properties, mechanical analysis and characterization of arteries - Experimental identification of constitutive model parameters - Mechanical characterization of trabecular bone -Material properties, mechanical analysis and characterization of single cells and molecules.

UNIT V INSTRUMENTATION 12

Small scale mechanical characterization including: nanoindentation, thin film bulge test, and electron microscopy methods. Nanoindentation: Force control and displacement control – common sources of artifacts – Nanoindentation instrumentation - Atomistic theories of tip-sample interaction- Oliver-Pharr method – other techniques of Nanoindentation – Different types of nanoindentation

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the Nanoindentation testing methods in biological materials

REFERENCES

1. Nonlinear solid mechanics: a continuum approach for engineering, Gerhard A. Holzapfel John Wiley & Sons, Chichester, 2nd ed. (2004)
2. Nonlinear theory of elasticity – Application in biomechanics / Larry A. Taber World Scientific Publishing Co Pte Ltd (2004)
3. Biomechanics: Concepts and Computations / Cees Oomens, Marcel Brekelmans and Frank Baaijens Cambridge University Press (2009)
4. Michelle L. Oyen, Handbook of Nanoindentation: With Biological Applications, Pan Stanford Publishing, 2010
5. Nanoindentation in Materials Science" ed. by Jiří Němeček, Publishers InTeOp, 2012, ISBN: 9535108023 9789535108023

PX7016 METHODS OF CHARACTERIZATION OF NANOMATERIALS

L	T	P	C
4	0	0	4

OBJECTIVE

- To expose the students with knowledge of understanding the basic characterization of nanomaterials

UNIT I X-RAY ANALYSIS OF NANOMATERIALS 12

Powder X-ray diffraction – powder diffraction techniques - Debye-Scherrer technique – indexing the powder pattern – calculation of particle size using Scherer method – problems associated with Scherer method –Weber-Fechner method for particle size analysis - Selected area diffraction - Low angle scattering - High resolution X-ray diffractometer (two and four crystal).

UNIT II SURFACE ANALYTICAL TOOLS FOR NANO-MATERIALS 12

UV and X-ray photoelectron spectroscopy; Auger electron spectroscopy; low energy electron diffraction and reflection high energy electron diffraction - secondary ion mass spectrometry - Rutherford backscattering - Medium energy ion scattering- Electron energy loss spectroscopy (EELS) and high resolution EELS. X-ray Photoelectron Spectroscopy, Auger photoelectron Spectroscopy.

UNIT III NANOSCALE ELECTRICAL SPECTROSCOPY 12

I-V/C-V; Hall, quantum Hall effects; transient charge spectroscopy. Optical spectroscopy: micro Photoluminescence; Absorption Spectroscopy, Excitation Spectroscopy, micro Raman Spectroscopy; Time domain spectroscopy.

UNIT IV ELECTRON MICROSCOPY 12

Principle of SEM – EDAX analysis- standardization of elements - nanoSEM, basic principles-STM - STEM - sample preparation – nanoparticles – thin films – TEM - High resolution TEM .

UNIT V NANO-IMAGING SPECTROSCOPY 12

Basic principles - Scanning Tunneling Microscopy, Scanning Force Microscopy (SFM/AFM), and scanning holographic microscopy -image interpretations; Scanning Near Field Optical Microscopy and scanning ion conductance microscopy.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the various techniques used for analyzing the nanomaterials.

REFERENCES

1. G. Gao. Nanostructures and Nanomaterials. Imperial College Press, London, 2006
2. Y. Gogotsi. Nanomaterials Handbook. CRC Taylor and Francis, New York, 2006

PX7017	MODERN ALTERNATIVE ENERGY CONVERSION DEVICES	L	T	P	C
		4	0	0	4

OBJECTIVE:

- To introduce knowledge on alternative energy sources

UNIT I INTRODUCTION TO ALTERNATIVE ENERGY SOURCES AND UTILIZATION 12

Principles of energy conversion: thermodynamic first and second laws, energy balances - Solar energy: Solar intensity and spectrum, global solar energy potential and current level of utilization, Photovoltaic - history, principles and theoretical limits. Solar cells – Batteries – Hydrogen storage materials – wind energy – Geothermal energy – Power from Water - Biomass - thermal power plants – Economy on energy projects – Utilizations.

UNIT II FUNDAMENTALS OF ELECTROCHEMISTRY AND ELECTRODE KINETICS 12

Introduction to Electrochemistry - Charge transfer reaction and reaction kinetics – Interface – Defects chemistry – Electrocatalysis – Electrochemical Reactors – Cell – Configuations and classifications - Electrode Processes – Potential and thermodynamics of a Cell – Electroactive layers – modified electrodes - Cell stack and thermal management.

UNIT III HYDROGEN AS A RENEWABLE ENERGY SOURCE 12

Fuel cell – Principle of working, construction - Characteristics and Classifications of Fuel Cells – Hybrid Fuel Cells – Electrical Vehicles – applications. Hydrogen Production: Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production- Storage of Hydrogen: Gaseous, Cryogenic and Metal hydride-Environmental impact.

UNIT IV BATTERIES AND SUPER CAPACITORS 12

Introduction to Primary and Secondary batteries- Principle- Battery materials - anode, cathode and electrolyte materials - Concepts of Rechargeable batteries – Applications of Lithium batteries, Lithium ion and polymer batteries. –- Super-capacitors: principles and working, electrode materials synthesis process, fabrication of the devices and their applications.

UNIT V BIOMASS UTILIZATION AND NUCLEAR ENERGY 12

Biodiesel and ethanol, Biomass utilization, Nuclear Energy: Potential of Nuclear Energy, International Nuclear Energy Policies and Regulations. Nuclear Energy Technologies – Fuel enrichment, Different Types of Nuclear Reactors, Nuclear Waste Disposal, and Nuclear Fusion.

TOTAL: 60 PERIODS

OUTCOME

- The students will understand the importance of alternate energy sources and basics of various energy conversion devices.

REFERENCES

1. Renewable Energy Sources and Conversion Technology. Bansal, N K, Kleemann, M, Meliss, M , Tata McGraw-Hill Publishing Company Ltd., New Delhi. (1990)
2. Renewable Energy Sources and Emerging Technologies , Kothari D.P., Singal K.C., Ranjan Rakesh, PHI Publishers, 2nd Edition, (2011).
3. Electrochemical Supercapacitors , B.E. Conway, Springer Science and Business Media, (1999)
4. Lithium Batteries – Science and Technology – Gholam-Abbas Nazri, Gian Franco Pistoria (Eds.) Springer Science and Business Media (2009)
5. The CRC handbook of solid state electrochemistry, P.J> Gellings, H.J.M>, Bouwneester (Eds.), CRC Press, (1996)
6. Electrochemical Methods – Fundamental and Applications , Allen J. Bard, Larry R. Fauliener, 2nd Edition, John Wiley & Sons, Inc (2000)
7. Fuel Cell Fundamentals: O'Hayre, Suk-Won Cha, Whitney Colella, and Fritz B. Prinz, 2nd ed, John Wiley & Sons, New York. (2008)
8. Energy Storage Materials: S.Selladurai, 2010

PX7018	MOLECULAR BIOPHYSICS	L T P C
		4 0 0 4

OBJECTIVE:

- To study the basic concepts of molecular biophysics

UNIT I INTRAMOLECULAR INTERACTIONS 12

Contact distance criteria - van der Wall's interactions - Electrostatic interactions – Hydrogen Bonding interactions - Distortional energies - Description of various interactions by potential functions.

UNIT II STRUCTURE OF PROTEINS 12

Peptide bond and peptide unit - *cis* and *trans* configuration - phi and psi conventions - streic hindrance - allowed conformations - Ramachandran diagram - conformational maps for glycine and other natural amino acids - energy maps - patterns of folding - primary, secondary, ternary and quaternary structures - supersecondary and domain structures - types of secondary structures - alpha helix, beta sheets, reverse turns - structures of fibrous and globular proteins - collagen, hemoglobin and lysozyme.

UNIT III STRUCTURE OF NUCLEI C ACIDS 12

Nucleosides and nucleotides - tautomeric equilibria of bases - ionisation equilibria of nucleosides and nucleotides - conformation of nucleosides and nucleotides - structure and conformation of oligonucleotides - base pairing interactions - base stacking interactions - double helical model of DNA - DNA polymorphism - structures of A, B and Z – DNA, structure of TRNA.

UNIT IV STRUCTURE OF POLYSACCHARIDES 12

Monosaccharides - stereoisomerism of hexapyranose sugars - structure and conformation of maltose, cellobiose, cellulose amylose and chitin.

UNIT V BIOMOLECULAR ASSEMBLY 12

Molecular models for membrane structures and conformation of phospholipids, membrane proteins - Structure of chromatin, nucleosomes, polynucleosomes and viruses.

TOTAL: 60 PERIODS

OUTCOME

- To provide the knowledge on the basic concepts of intermolecular interactions, structure of proteins, nuclei acids, polysaccharides and biomolecular assembly.

REFERENCES

1. Cantor, C.R. and Schimmel, P.R., "Biophysical Chemistry Part 1,2 and 3", W.H.Freeman and Co., San Fransisco, USA, 1980.
2. Senger W., "Principles of Nucleic Acid Structure", Springer Verlag, Germany, 1984.
3. Schulz, G.E. and Schirmer, R.H. "Principles of Protein Structure", Springer Verlag, West Germany, 2009.
4. Narayanan, P., "Essentials of Biophysics", New Age International, New Delhi, 2007.

PX7019 NONLINEAR DYNAMICS OF NANODEVICES AND SYSTEMS

L	T	P	C
4	0	0	4

OBJECTIVE

- To prepare the students to understand the concepts of nonlinear dynamics in nanodevices and systems

UNIT I NONEQUILIBRIUM NANOSYSTEMS 12

Introduction – statistical thermodynamics of nonequilibrium nanosystems – mechanical nanosystems – mechanochemical nanosystems – chemical nanosystems – chaotic dynamics of chemical systems – thermodynamics of small systems-– quantum dissipative ratchets.

UNIT II SURFACE EFFECTS 12

Introduction – dynamics of nanoscopic capillary waves – Nonlinear dynamics of surface steps – Casimir forces and geometry in nanosystems.

UNIT III NANOELECTROMECHANICS 12

Introduction – review of motion – nanomechanical oscillators – faint forces – Duffing oscillator model – nanomechanical resonators – AFM and its control for nanoparticle manipulation.

UNIT IV NANOELECTRONICS 12

Introduction – quantum transport: normal and chaotic conductors – quantum transmission – diagonal contribution – nonlinear response of driven mesoscopic conductors – perturbation theory and reduced density operator – spinless electrons – transport under multi-photon emission and absorption – electron pumping – pattern formation and time delayed feedback control at nanoscale.

UNIT V OPTIC-ELECTRONIC COUPLING 12

Introduction – laser assisted electron transport in nanoscale devices – plasmonic nanostructures – dynamics of nonlinear light propagation in complex photonic lattices.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on the analysis of nonlinear dynamical effects in nanosystems.

REFERENCES

1. M. Lakshmanan and K. Murali, "Chaotic oscillators: Controlling and synchronization", World Scientific, Singapore (1996).
2. M. Lakshmanan and S. Rajasekar, "Nonlinear dynamics: Integrability, chaos and patterns", Springer, Berlin (2001).

3. G. Radons, B. Rumpf and H.G. Schuster, “Nonlinear dynamics of nanosystems”, Wiley-VCH, Weihheim (2010).
4. B. Rogers, S. Pennathur and J. Adams, “Nanotechnology: Understanding small systems”, CRC
Press, Boca Raton (2008).
5. S.H.Strogatz, “Nonlinear dynamics and chaos”, Addison-Wesley, Manchester (1994).

PX7020 NONLINEAR SCIENCE: SOLITONS AND CHAOS

L	T	P	C
4	0	0	4

OBJECTIVE

- To enlighten the students about the basic concepts of nonlinear science: solitons and chaos.

UNIT I GENERAL 12

Linear waves-ordinary differential equations(ODEs)-Partial differential equations(PDEs)-Methods to solve ODEs and PDEs.- Numerical methods – Linear and Nonlinear oscillators-Nonlinear waves-Qqualitative features.

UNIT II COHERENT STRUCTURES 12

Linear and Nonlinear dispersive waves - Solitons – KdB equation – Basic theory of KdB equation – Ubiquitous soliton equations – AKNS Method, Backlund transformation, Hirota bilinearization method, Painleve analysis - Perturbation methods- Solitons in Optical fibres - Applications.

UNIT III BIFURCATIONS AND ONSET OF CHAOS 12

One dimensional flows – Two dimensional flows – Phase plane – Limit cycles – Simple bifurcations – Discrete Dinamical system – Strange attractors – Routes to chaos.

UNIT IV CHAOS THEORY AND CHARACTERISTION 12

One dimensional maps – Duffing oscillators – Lorenz equations – BVP and DVP oscillators – Pendulum – Chaos in nonlinear circuits – Chaos in conservative system – characterization of chaos –Fractals.

UNIT V APPLICATIONS 12

Soliton based communication systems – Solition based computation – Synchronization of chaos – Chaos based communication – Cryptography – Image processing – Stochastic – Resonance – Chaos based computation – Time Series analysis.

TOTAL: 60 PERIODS

OUTCOME

- The students will understand the general mathematical concepts of partial differential equation, nonlinear waves, coherent structures, bifurcation and onset of chaos, chaos theory & characterization and applications.

REFERENCES

1. M.Lakshmanan and S.Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, Berlin 2003
2. A.Hasegawa and Y.Kodama, Solitons in Optical Communications, Oxford Press, 1995.
3. G.Drazin and R.S.Johnson, Solitons: An Introduction, Cambridge University Press,1989.
4. M.Lakshmanan and K.Murali, Chaos in Nonlinear Oscillators, World Scientific, Singapore, 1989.
5. S.Strogatz, Nonlinear Dynamics and Chaos, Addison Wesley, 1995.

PX7021 **SOLID STATE PHYSICS** **L T P C**
4 0 0 4

OBJECTIVE

- To expose the students with the theoretical concepts of Solid State Physics.

UNIT I CRYSTAL STRUCTURE AND BINDING 12

Symmetry - crystal lattice - unit cell (conventional and Wigner-seitz unit cell) - crystal structures - reciprocal lattice - Brillouin zone - crystallographic point groups and space groups - force between atoms - cohesive energy - bonding in solids - ionic, covalent, metallic - hydrogen bonded crystals.

UNIT II ELECTRONIC PROPERTIES 12

Free electron theory (classical and quantum) - electronic specific heat - electrical and thermal transports - failures of free electron model - periodic crystalline potential - Bloch theorem - formation of energy bands - classification of solids - effective mass and concept of hole - intrinsic and extrinsic semiconductors - direct and indirect bandgap of semiconductors - Fermi surface of metals.

UNIT III LATTICE DYNAMICS 12

Vibration modes of mono and diatomic lattices - quantization of lattice vibration - lattice specific heat theories (Einstein and Debye models) - phonon momentum - scattering of neutrons by phonons - neutron diffraction - lattice thermal conductivity - normal and Umklapp process – anharmonicity and thermal expansion

UNIT IV DIELECTRIC AND OPTICAL PROPERTIES 12

Polarization - theory of polarizability - Clausius-Mossotti relation - piezo - pyro and ferroelectric properties of crystals - antiferroelectricity and ferrielectricity - absorption process in semiconductors - photoconductivity - photoluminescence - Defects in crystals- color centers

UNIT V MAGNETIC PROPERTIES AND SUPERCONDUCTIVITY 12

Classification of magnetic materials - Hund's rule - ferromagnetic order - Curie point - exchange integral - saturation magnetization - origin of domains - magnons - electron-phonon interaction - cooper pairs - BCS theory - energy gap and its temperature dependence - London equation - Josephson effect - high temperature superconductivity.

TOTAL: 60 PERIODS

OUTCOME

- The students will acquire knowledge on crystal structure and binding, electronic properties, lattice dynamics, dielectric & optical properties and magnetic and superconducting properties of materials.

REFERENCES

1. C.Kittel, "Introduction to Solid State Physics", 7th Edn. Wiley Eastern, 1996.
2. A.K.Chandra, "Quantum Chemistry", Prentice Hall 1990.
3. R.E.Hummel, "Electronic properties of materials", Narosa, 1993.
4. S.Raimes, "The wave mechanics of electrons in metals", North Holland, 1967.
5. William D. Callister, David G. Rethwisch " Fundamentals of Material science and Engineering an Introduction", sixth edition, Wiley India, New Delhi, 2009.
6. N.W. Ashcroft and N. D. Mermin, "Solid state Physics" Saunders 1976.
7. A.J Dekker, Solid State Physics, Prentice Hall 1957.

PX7022 **SPECTROSCOPIC TECHNIQUES** **L T P C**
4 0 0 4

OBJECTIVE

- To introduce the basic concepts and applications of various spectroscopic techniques.

UNIT I INFRARED SPECTROSCOPY 12

Electromagnetic spectrum – absorption and emission spectra - Vibrational study of diatomic molecules – IR rotation – Vibrational spectra of gaseous diatomic molecules – simple gaseous polyatomic molecules – vibrational frequencies and qualitative analysis – Quantitative IR analysis – determination of bond length and bond moment – determination of interstellar atoms and molecules – IR spectrometer – elementary ideas of FT-IR.

UNIT II RAMAN SPECTROSCOPY 12

Raman effect – Raman shift – definition – observation of Raman spectra – Raman spectrometer – Quantum theory of Raman effect – probability of energy transition in Raman effect – Vibrational Raman spectra – structure determination from Raman and IR spectroscopy – SERS- Instrumentation and sampling Techniques – Non Linear Raman effects: inverse Raman effect – CARS – Applications.

UNIT III SEM –EDX AND FT-IR MICROSPECTROSCOPY 12

SEM imaging process: Scanning action – image construction (mapping) – magnification – Picture Element – Depth of Field – Image distortion.-Specimen preparation for SEM: Soils and Clays – polymers. EDX principle and application - Origin of FT-IR Micro spectroscopy -Basic principle- Schematic diagram and Working of FT-IR microspectrometer- Applications (Polymer science, Drug delivery system and Living cells)-Limitations

UNIT IV ESR SPECTROSCOPY 12

Origin of electron spin resonance and resonance condition – quantum mechanical theory of ESR – design of ESR spectrometer – Hyperfine structure study – ESR study of anisotropic systems – Triplet states study of ESR – application of ESR to transition metal ions.

UNIT V NQR AND MOSSBAUER SPECTROSCOPY 12

General principles of NQR – energy levels of quadruple transitions for half-integral spins – design of NQR Spectrometer – Application of NQR (Molecular Structure). Principle of Mossbauer Effect – Schematic arrangement of Mossbauer spectrometer – Isomer shift – Quadruple interaction – magnetic hyperfine interactions – applications of Mossbauer spectroscopy (Biological applications)

TOTAL: 60 PERIODS

OUTCOME

- The students will understand various spectroscopic methods, principles, experimental techniques and their applications

REFERENCES

1. C.N.Banwell and E.M.McCash Fundamentals of Molecular Spectroscopy, Mc Graw Hill Education India Pvt. Ltd., 2013.
2. B.P.Straughan and Walkar.S, Spectroscopy Vol.1 & 2, Chapman & Hall, 1976.
3. G.Aruldhas, Molecular structure and Spectroscopy, Prentice-Hall of India, 2005.
4. Joseph. I. Goldstein et al, Scanning Election Microscopy and X-ray Microanalysis, Plenum Press. New York, 1984.
5. E.Wertz and R.Bolton, Electron Spin Resonance, Chapman and Hall Co., New York, 2000.
6. N.N.Green wood & T.C.Gibb., Mossbauer Spectroscopy, Chapman & Hall, 1971.
7. EPR Elementary theory and Practical applications – J.E.Wertz and J.R.Boulton.Mc Graw Hill 1972.
8. W.T.Dixon, Theory and Interpretation of Magnetic resonance spectra, Plenum press, 1972.

PX7023 SUPERCONDUCTIVITY AND ITS APPLICATIONS

L	T	P	C
4	0	0	4

OBJECTIVE:

- To enlighten the students with the concepts of superconductivity.

UNIT I BASIC EXPERIMENTAL ASPECTS 12

Zero electrical resistance – Meissner effect – A C diamagnetic susceptibility – heat capacity – optical absorption by superconductor – entropy change –thermal conductivity – destruction of superconductivity by external magnetic fields – type I and type II materials – superconducting behaviour under high pressures –flux quantisation – normal and Josephson tunneling.

UNIT II SUPERCONDUCTING MATERIALS 12

Elemental superconductors – superconducting compounds and its alloys – A15 compounds – chevral phase compounds

UNIT III HIGH TEMPERATURE SUPERCONDUCTORS 12

La-Ba-Cu-O, Y-Ba-cu-O, Bi-Sr-Ca-Cu-O and new systems and their crystal structures – Experimental studies on the new materials – organic superconductors –fullerenes.

UNIT IV THEORETICAL ASPECTS 12

Isotope effect – BCS theory – Role of electrons and phonons – applications of electron band structure results to calculate electron – Phonon coupling constant, McMillan's formula – GLAG theory – recent theories on high Tc materials, Coherence length, expression for critical temperature Tc, critical field Hc, critical current Jc – heavy fermion superconductivity.

UNIT V APPLICATIONS 12

Superconducting magnets – power generators, motors, transformers, power storage, power transmission – Josephson junction devices – IR sensors – SQUIDS –SLUGS – magnetically leviated trains – computer storage elements.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on superconducting materials, theoretical aspects and the applications of superconductors.

REFERENCES

1. Narlikar. A.V. and Ekbote, "Introduction to superconductivity", South Asia publishers, 1983.
2. Tilley. D.R and Tilley. . "Superfluidity and superconductivity", Adam Hilger, 1986.
3. Hoi.S.Kowk and David T. Shaw (Eds.), "Superconductivity and its Applications", Elsevier Science
   Publishing, 1988.
4. Narlikar. A.V., "Studies on High temperature superconductors- Advances in research and applications" Nova Scientific, New Delhi, 1990.

PX7024 ULTRASONICS

L	T	P	C
4	0	0	4

OBJECTIVE

- To study the basic concepts of Ultrasonics.

UNIT I ULTRASONIC PROPAGATION IN SOLIDS AND LIQUIDS 12

Propagation of Ultrasonics waves in solids – Plane wave propagation - Relation of the velocity of sound to the elastic properties – Adiabatic and Isothermal elastic constants – Ultrasonic propagation in liquids – Internal pressure and free volume calculations.

Attested

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UNIT II DETERMINATION OF VELOCITY OF PROPAGATION OF ULTRASONICS 12

Pulse Echo methods – Phase comparison methods – Pulse superposition – Measurements at high Pressure and high temperature–Transducer Coupling materials.

UNIT III ULTRASONIC TRANSDUCERS 12

Piezoelectric and magnetostrictive transducers – Equivalent circuits – Efficiency – Transducer mounting – Linear and sector transducers – Variable frequency systems.

UNIT IV ABSORPTION OF ULTRASONIC RADIATION 12

Classical absorption due to viscocity – Absorption due to thermal conductivity – Relaxation processes – Evaluation of dispersion and absorption curves – Structural relaxation – Relation between collision frequency and relaxation time – Ultrasonic attenuation in solids.

UNIT V APPLICATIONS OF ULTRASONICS 12

Applications of Ultrasonics in NDT – Medical Applications – Biological effects of Ultrasound – Different modes of scanning – Doppler Ultrasound techniques -Ultrasonic transaxial tomogram (U.T.T.) – Acoustic microscope-Acoustic hologram.

TOTAL: 60 PERIODS

OUTCOME

- The students will gain knowledge on propagation of ultrasonic waves in medium and determination of its velocity, ultrasonic transducers, absorption of ultrasonic radiation and applications of ultrasonics.

REFERENCES

1. Gooberman G.L., “Ultrasonics-Theory and Applications“, The English Universities Press Ltd., London, 1968.
2. Schreiber Edward, “Elastic Constants and their measurement”, Anderson and Soga, McGraw Hill Book Co., New Delhi 1973.
3. Lerski R.A. (Ed), “Practical Ultrasound”, IRL Press, Oxford, 1988.
4. Robert T.Beyer and Stephen V. Letcher, “Physical Ultrasonics”, Academic Press London, 1969.
5. Woodcock J.P., “Ultrasonics”, Adam Hilger Ltd., U.K., 1979.