J C BOSE UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA, FARIDABAD

Department of Physics: Scheme for Ph.D. (Physics)

Compulsory Papers: Each student will study the following compulsory papers:

Paper Code	Course Title	Teaching Schedule			Marks for Sessional	Marks for End Term Examination		Total Marks	Credits
		L	P	TOTAL		Theory	Practical		
PHD-100A	Research Methodology	4	0	4	25	75	0	100	4
CPE-RPE	Research and Publication Ethics	2	0	2	25	75	0	100	2

#Optional Papers: Students have to choose one optional paper out of the followings:

Paper Code	Course Title	Teaching Schedule			Marks for Sessional	Marks for End Term Examination		Total Marks	Credits
		L	P	TOTAL		Theory	Practical		
PHDP-01	Smart Materials and Characterization	4	0	4	25	75	0	100	4
PHDP-02	Plasma State of Matter	4	0	4	25	75	0	100	4
PHDP-03	Nano Materials and Characterization	4	0	4	25	75	0	100	4
PHDP-04	Functional Materials-Properties and Characterization Techniques	4	0	4	25	75	0	100	4
PHAS-112	Nuclear Instrumentations	4	0	4	25	75	0	100	4
	Total	10	0	10	75	225	0	300	10

Note: Exam duration will be of 3 hours.

 # More optional papers may added to the scheme as per requirement.

Subject: Smart Materials and Characterization
Paper code: PHDP-01
NO OF CREDITS: 4

SESSIONAL: 25

L	P
4	0

THEORY EXAM: 75

TOTAL: 100

UNIT I

Materials Science and Engineering

Metals, Ceramics and Glasses, Polymers and Composites**,** Smart materials exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers**,** photoconductivity and superconductivity, nanomaterials - synthesis, properties and applications, biomaterials, superalloys, shape memory alloys.

UNIT II

Advanced Techniques for Materials Characterization I

Electron Microscopy: Interaction of electrons with solids, Scanning electron microscopy transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Electron energy loss spectroscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.
Diffraction Methods: Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction, Neutron diffraction.

Unit III

Advanced Techniques for Materials Characterization II

Surface Analysis: Atomic force microscopy, Scanning tunneling microscopy, Secondary ion mass spectrometry, Auger electron spectroscopy, X-ray photoelectron spectroscopy.
Spectroscopy: Optical emission spectroscopy, Atomic absorption spectroscopy, UV/Visible spectroscopy, Spark source mass spectrometry, Raman

spectroscopy, Infrared spectroscopy, Fourier transform infrared spectroscopy, X-ray fluorescence, Inductively coupled plasma emission spectroscopy, Rutherford backscattering spectroscopy.

UNIT IV

Thermodynamics of materials

Thermodynamics definitions, the Zeroth Law, temperature, Equations of State and state variables, Changes of state, work and heat, internal energy and enthalpy, the 1st Law, state functions, thermochemistry, Entropy, the 2nd Law, reversibility and irreversibility, Thermodynamic postulates, fundamental relations, Gibbs equations, thermodynamic transformations, Phase equilibria, pure, Mixtures and solutions, Chemical equilibria, Surface Thermodynamics, Reaction Kinetics, Diffusion in Solids, Mass Transfer in Fluid Systems,

Books:

1. Cullity, B.D. Elements of X-Ray Diffraction, Addison Wesley (1967).
2. Smallman, R.E., and Bishop, R.J., Metals and Materials – Science, Processes, Applications, Butterworth-Heinemann (1995).
3. Sibilia J.P., A Guide to Materials Characterization and Chemical Analysis, VCH (1988).
4. W. D. Callister: Fundamentls of Materials Science and Engineering, Wiley (2007)
5. C. Kittle: Introduction to Solid State Physics, Wiley (2007)
6. A K Bandopadhyay:Nanomaterials, New Age international publication
7. R. A. Swalin, Thermodynamics of Solids, John Wiley and Sons, 1972.
8. C. H. P. Lupis, Chemical Thermodynamics of Materials, Elsevier Science Publishing Co., New York,2001.

SUBJECT-PLASMA STATE OF MATTER
PAPER CODE – PHDP-02
No of Credits-04

L 4		SESSIONAL: 25
P 0		THEORY EXAM: 75

UNIT I: EXCITATION AND IONISATION IN A GAS

Ionisation by collision ; Townsend' theory of collision ionisation; Thermal ionisation and Excitation; Ionisation by radio frequency field ;Theory of Ionisation by collision Kihara's theory; Breakdown of gases; Ionisation by shock wave; Plasma production by Laser; Recombination.

UNIT II: FUNDAMENTAL CONCEPTS OF PLASMA

Kinetic pressure in a partially ionised gas; Mobility of charged particles; Effect of magnetic field on the mobility of ions and electrons ; Diffusion of ion and electrons; Diffusion in magnetic field; Thermal conductivity; Effect of magnetic field, electron and ion temperature; Dielectric constant of plasma; Quasineutrality of Plasma, Debye Shielding distance; optical properties of plasma, Magnetic susceptibility of plasma.

UNIT III: THERMAL NUCLEAR POWER

Nuclear reaction rate; criterion for a reactor system; Plasma production; heating of plasma; Confinement of Plasma.

UNIT IV: IONOSPHERIC PLASMA

The ionosphere; Effect of collision on reflection of radio wave, Effect of magnetic field on radio wave propagation-Magneto ionic theory; Appleton Hartree formula including the collision term; Radio sounding of the ionosphere; Structure of the ionosphere ; maximum usable frequency and skip distance; Formation of Ionospheric layer; Chapman's theory of formation of ionospheric layers;

REFERENCE BOOKS:

1.Classical Electrodynamics by J.D. Jackson.
2. Introduction to Electrodynamics by D. J. Griffiths.
3. Introduction to Plasma Physics by Francis F. Chen.
4. Introduction to Electrodynamics by A. Z. Capri and P. V. Panat
5. Plasma Physics by S. N. Sen.

NANO MATERIALS AND CHARACTERIZATION
PAPER CODE- PHDP-03
No of Credits 4

L - 04	External Exam: 75
P - 0	Internal Assessment: 25

Unit I

Introduction of Nano Materials:

Solid Nanostructures, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon. Carbon Nanostructures: Fullerene family, Carbon Nanotubes, Nanodiamond, BN Nanotubes.

Unit II.

Quantum Mechanics for Nano Materials:

Size Dependence of Properties, Quantum Size effect, Quantum Confinement for 3-D,2-D,1-D and 0-D, Density of States for Three Dimension (Bulk), Two Dimension (Quantum Well), One Dimension (Quantum Wire), Zero Dimension (Quantum Dot).

Unit III

Growth Techniques of Nano Materials:

Top-down vs. Bottom-up Technique, Lithographic Process and its Limitations, Nonlithographic Techniques, Plasma Arc Discharge, Sputtering, Chemical Vapour Deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy, Sol–Gel Technique, Electrodeposition.

Unit IV

Characterization Techniques of Nano Materials:

Scanning Probe Microscopy (SPM), Scanning Electron Microscope (SEM),Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), UV-Visible Spectroscopy, Fourier transform infrared spectroscopy (FTIR), Raman Spectroscopy, Thermoluminescence, Photoluminescence (PL), X-ray diffraction (XRD).

REFERENCES:

1. Nanoscale materials -Liz Marzan and Kamat
2. 'Handbook of Theoretical and Computational Nanotechnology, Eds. Michael Rieth and Wolfram Schommers, 2006.
3. Introduction to Nanoscience and Nanotechnology,K.K. Chattopadhyay and A.N. Banerjee
4. Nano Engineering in Science & Technology : An introduction to the world of nano design by Michael Rieth.
5. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing

Functional Materials: Properties and Characterization Techniques
Paper code: PHDP-04
No. of Credits: 4

		SESSIONAL:	25
L	P	THEORY EXAM:	75
4	0	TOTAL:	100

UNIT I: Functional Materials

Polymers: Introduction to polymers and their classification, Conjugated and non-conjugated polymers, origin of conductivity & charge transport mechanism in polymers. Methods of synthesis of conjugated polymers, composites of Polymer: polymer-polymer composites and metal oxide – polymer composites, properties and applications of polymers and their composites.

Ceramics: Introduction to ceramic materials and their classification, electro-ceramics: dielectrics, piezoelectrics, pyrroelectrics, ferroelectrics. Applications of electro-ceramic materials, ferroelectric phase transition and Curie-weiss Law, Relaxor ferroelectrics. Solid state reaction method of synthesis, their properties and applications.

UNIT II: Fundamentals of Nanotechnology and Sensors

Nanomaterials – Introduction to 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Top down and Bottom up approach, Ball milling, Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Chemical vapor deposition (CVD). Sputtering, pulsed laser deposition, chemical oxidation, electrochemical method, chemical reduction method: hydrothermal method, Opto-electric Properties of nanomaterials and their applications.

Sensors: Introduction to sensors, basic sensing mechanism; types of sensors: Chemical, electrical and optical sensors, Gas sensors, Characteristics of sensors**.**

UNIT III: Electrical Measurement & Characterization Techniques

Impedance measurements and AC conductivity, Electric Polarization and Relaxation in Static and Time-Varying Electric Fields, The Mechanisms of Electric Polarization, Temperature, frequency and Field Dependence of Complex Permittivity, Ferroelectric and Piezoelectric Parameters and their Measurements.

Electrical Conduction and Photo conduction: I-V characteristics, static and transient response, DC conductivity: two probe and four probe methods and their applications, various conduction mechanisms in solids, bulk limited and space charge limited conduction mechanism, cyclic-voltametry measurements.

Unit IV: Structure Measurement & Spectroscopic Techniques

Structure Analysis Techniques: Fundamentals of crystallography, Basic principle and Theory, Instrumentation and methods of measurements of the following structure measurement techniques X-Ray diffraction technique, Atomic force microscopy, Scanning electron microscopy, transmission electron microscopy and specimen preparation techniques.

Spectroscopic Techniques: Basic principle and Theory, Instrumentation and methods of measurements of the following spectroscopic techniques: UV-Visible spectroscopy, Photoluminescence studies, Fluorescence and Phosphorescence, FTIR spectroscopy, Raman spectroscopy, Atomic absorption spectroscopy, X-ray photoelectron spectroscopy; Applications of the spectroscopic techniques.

Books:

1. F.W. Billmeyer Jr., Textbook of Polymer Science, Wiley Interscience, New York, (2005).
2. T. Blythe and Bloor D., Electrical Properties of Polymers, Cambridge University Press, New York, USA, (2005).
3. P. Chandrasekhar, Conducting Polymers, Fundamentals and Applications: A Practical Approach, Kluwer Academic Publishers, USA, P. (1999).
4. A K Bandopadhyay:Nanomaterials, New Age international publication.
5. L.Y. Kupriyanov Handbook of sensors and Actuat., semiconductor sensors in physico-chemical studies, Elsevier, Amsterdam, 4 (1996).
6. J. Fraden, Handbook of Modern Sensors: Phys., Designs, and Applications, 3rd ed. New York: AIP Press/Springer (2004).
7. E. Barsoukov & R. Macdonald, Impedance Spectroscopy Theory, Experiment, and Applications, Wiley-Interscience, New Jersey (2005).
8. K.C. Kao, Dielectric Phenomena in Solids, Elsevier (2004).
9. Cullity, B.D. Elements of X-Ray Diffraction, Addison Wesley (1967).
10. C. Kittle: Introduction to Solid State Physics, Wiley (2007)
11. D.R. Vij, Handbook of Applied Solid State Spectroscopy, Springer (2006).
12. S. Wartewig, IR and Raman spectroscopy, WILEY-VCH Weinheim.