SIDDHARTHA
ACADEMY OF HIGHER EDUCATION
An Institution DEEMED TO BE UNIVERSITY
(Under Section 3 of UGC Act, 1956)
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Department of Physics

POOL I Courses

S.No	Course Code	Title of the Course	L	T	C	Total
1	24PH710A	Glass Science and Technology	3	0	3	100
2	24PH710B	Liquid Crystals I	3	0	3	100
3	24PH710C	Materials Science	3	0	3	100
4	24PH710D	Mathematical Physics	3	0	3	100
5	24PH710E	Nano Science and Nanotechnology	3	0	3	100
6	24PH710F	Nanomaterials and their Properties (NPTEL)	3	0	3	100
7	24PH710G	Fundamentals of Spectroscopy (NPTEL)	0	0	3	100
8	24PH710H	Physics of Materials (NPTEL)	0	0	3	100

POOL II Courses

S.No	Course Code	Title of the Course	L	T	C	Total
1	24PH720A	Functional Nano Materials	3	0	3	100
2	24PH720B	Glass Properties	3	0	3	100
3	24PH720C	Liquid Crystals II	3	0	3	100
4	24PH720D	Materials Characterization Techniques	3	0	3	100
5	24PH720E	Physics of Advanced Materials	3	0	3	100
6	24PH720F	Materials Characterization (NPTEL)	0	0	3	100
7	24PH720G	Glass Processing Technology (NPTEL)	0	0	3	100
8	24PH720H	Physics of Functional Materials and Devices (NPTEL)	0	0	3	100

POOL I — COURSES SYLLABUS

24PH710A
GLASS SCIENCE AND TECHNOLOGY

Unit 1: Introduction to Glass, Principles of Glass Formation and Melts (09 hours)

Definition of a Glass, The Enthalpy/Temperature Diagram, Structural Theories of Glass Formation, Kinetic Theories of Glass Formation – Nucleation - Crystal Growth, General Kinetic Treatment of Glass Formation, Determination of Glass Forming Ability & Glass Stability, Raw Materials, Compositional Nomenclature, Batch Calculations, Mechanisms of Batch Melting, Fining of Melts, Homogenizing of Melts, Specialized Melting Methods.

Unit 2: Structures of Glasses (09 hours)

Introduction, Fundamental Law of Structural Models, Elements of Structural Models for Glasses, Structural Models for Silicate Glasses, Structural Models for Borate Glasses, Structural Models for Germanate Glasses, Structural Models for Phosphate Glasses, Structures of Other Inorganic Oxide Glasses, Halide Glasses, Chalcogenide Glasses, Organic Glasses, and Amorphous Metals.

Unit 3: Glass Melting (09 hours)

Introduction, Raw Materials, Compositional Nomenclature, Batch Calculations, Mechanisms of Batch Melting, Fining of Melts, Homogenizing of Melts, Specialized Melting Methods.

Unit 4: Glass Technology (09 hours)

Introduction, Classical Forming Methods - Containers - Flat Glass, Glass Fibers, Glass Tubing and Rod, Solid and Hollow Glass Spheres, Lamp Glass, Optical Fibers, Glass-Ceramics, Porous Glass, Dental Products, Sealing and Solder Glasses, Vitreous Silica Product, Sol-Gel Processing, Specialized Forming Methods.

Unit 5: Compositions and Properties of Commercial Glasses (09 hours)

Introduction, Vitreous Silica, Soda-Lime-Silica Glasses, Borosilicate Glasses, Glass Fibers, Television Tube Glasses, Glass-Ceramics, and Other Commercial Glasses.

Reference Textbook:

Shelby, James E. *Introduction to Glass Science and Technology.* Royal Society of Chemistry, 2020.

24PH710B
LIQUID CRYSTALS - I

Unit 1: Chemical Constitution of Liquid Crystals (09 Hours)

Chemical constitution - Thermotropic Liquid Crystals - Nematic, Smectics, Cholesterics, and Disc-like Molecules - Achiral and Chiral Molecules - Occurrence of Ferroelectricity - Supra-molecular Design of Molecules - Banana Molecules, Lyotropic Liquid Crystals - Monolayer and Bilayer Arrangements - Monotropic and Enantiotropic Liquid Crystals - Bridging Groups - Chemical Moieties and their Influence for Mesomorphism.

Unit 2: Microscopic Investigations and Textures (09 Hours)

Microscopic investigations including basic concepts - Phenomenology and Morphology - Polymorphism - Boundary Effects - Textures - Homogeneous and Homeotropic Textures of Nematic and Smectic Phases.

Unit 3: Theories of Liquid Crystalline State (09 Hours)

Swarm Theory - Continuum Theory - Maier-Saupe Theory (Mean Field) - Landau-de Gennes Theory - Pre-transitional Effects - McMillan Theory of Smectic-A Phase and its Developments.

Unit 4: Electric and Magnetic Field Effects (09 Hours)

Elastic Deformation (Frederick's Deformation) - Magnetic Field Effects (Temperature) on Nematic and Smectics - Electric Field Effects - Domains - DSM - Loops - Electro-Hydrodynamic Instabilities.

Unit 5: Hydrogen Bonding and Supra-molecular Liquid Crystals (09 Hours)

Hydrogen Bonding and Supra-molecular Liquid Crystals: Chemical Moieties - Shape-based Classification of LCs - Metal-Organic Liquid Crystals - Bent Liquid Crystals - Hydrogen Bonding Liquid Crystals - Interaction Effects on Physical Properties - Types of HB LCs - Poly-phasic Liquid Crystals.

References:

1. P.G. de Gennes, *The Physics of Liquid Crystals*, Oxford University Press.
2. E.B. Priestley, *Introduction to Liquid Crystals*, Plenum Press.
3. S. Chandrasekhar, *Liquid Crystals*, Cambridge University Press.
4. G.R. Luckhurst and G.W. Gray, *The Molecular Physics of Liquid Crystals*, Academic Press.
5. 'Hand Book of Liquid Crystals' by T.Kato, Ed: D.Demus, J.Goodby, G.W.Gray, Ed: H.W.Spiess and v.vn (Weinheim: Wiley-VCH). 1998.
6. 'Thermotropic Liquid Crystals - Recent Advances' Ed: ARamamoorthy. Springer Press.
7. 'Alignment Technology and Applications of Liquid Crystal Devices' by Kohki Takatoh, Masaki Hasegawa et ai, Taylor Francis press.
8. 'Ferroelectric Liquid Crystals - Principles, Propeties and Applications' by J.W.Goodby, R.Blink, N.AClark, S.T.Lagerwall et al.
9. 'Ferroelectric Liquid Crystals' by B.Zeks and R.Blink, Gordon Breach.
10. H.Kihara, T.Kato, T.Uryu, S.Ujiie, U.Kumar, J.M.J.Frechet, D.W.Bruce and D.J.Price, Liq. Cryst., 21, (1996) 25; Z.Siderotou, D.Tsiourvas, C.M.Pa!eos and ASkoulios , Liq. Cryst., 22, (1997) 51; C.M.Paleos and D.Tsiourvas, Liq. Cryst., 28, (2001) 1127. T.C.Lubensky and L.Radzihovsky, Phy. Rev. E., 66, (2002) 031704

24PH710C
MATERIALS SCIENCE

Unit 1: Introduction to Materials (09 Hours)

Classification of Materials based on Function, Structure, Environmental, and Other Effects - Materials Design and Selection - Construction Materials, Electronic Materials, Magnetic Materials, Photonic Materials, Biomaterials, Organic Materials, Nanostructured Materials, and Composites.

Unit 2: Structure of Crystalline Solids (09 Hours)

Crystal Structure - Crystallographic Point, Direction, and Plane - Closed Packed Structures - Symmetry Elements - Symmetry Groups - Reciprocal Lattice - Construction of Reciprocal Lattices of SC, BCC, and FCC - Concept of Brillouin Zone - Crystalline and Non-crystalline Materials - Crystal Imperfections: Point Defects, Miscellaneous Imperfections, and Microscopic Examinations.

Unit 3: Microscopy (09 Hours)

Scanning Electron Microscopy - Field Emission-Scanning Electron Microscopy - Transmission Electron Microscopy - Selected Area Diffraction - Atomic Force Microscopy - Scanning Tunneling Microscopy - Low Energy Electron Microscopy.

Unit 4: Microanalysis of Materials (09 Hours)

Diffraction from Crystals and Crystal Structure Study - X-Ray Diffraction - UV-Visible Spectroscopy - Fourier Transform Infra-Red Spectroscopy - Raman Spectroscopy - Differential Scanning Calorimetry - Atomic Absorption Spectroscopy - Ellipsometry - Ultrasonic Characterization and Evaluations.

Unit 5: Science and Technology of Thin Films (09 Hours)

Basics of Thin Film Growth: Brief Review of Kinetic Theory, Adsorption, and Desorption - Nucleation and Growth - Epitaxy - Thin Film Control, Surfaces, Layered Structures - Physical Vapor Deposition - Chemical Vapor Deposition - Chemical Techniques: Spray Pyrolysis, Electro-Deposition, Sol-Gel Techniques - Basic Thin Film Characterization Techniques - Thickness Measurement, Phase Analysis, Optical Analysis, Morphology Analysis.

References:

1. The Science and Engineering of Materials, 5th ed, Donald R. Askeland and Pradeep P. Phulé, Thomson Learning, 2006.

2. Materials Science and Engineering: An Introduction, W D Calliester, Jr., John Wiley Sons, NY, 2007.

3. Science of Materials Engineering, 2nd Edition, C. M. Srivastava and C. Srinivasan, New Age International Publ., New Delhi, 2005.

4. Materials Characterization techniques, S. Zhang, L. Li and A. Kumar, CRC Press, Taylor Francis Group, NY, 2008.

5. Milton Ohring, The Materials Science of Thin Films, Academic Press, Sanden, 1992.

6. Kasturi L. Chopra, Thin Film Phenomena, McGraw Hill, NY, 1969

7. Materials Science of Thin Films, Milton Ohring, Second Edition, Acadamic Press, London.

8. "Spectroscopy with the Low Energy Electron Microscope". In Hawkes, Peter W.; Spence, John C. H. (eds.). Springer Handbook of Microscopy. Springer Handbooks. Springer International Publishing.

24PH710D: Mathematical Physics

Unit 1: Matrices and Linear System of Equations (8 Hours)

Introduction, Basic definitions, Inverse and Rank of a matrix, Consistency of a linear system of equations, Matrix inversion method, Gauss elimination, Gauss Jordan method, and the Eigenvalue problem.

Unit 2: Numerical Differentiation and Integration (9 Hours)

Introduction, Errors in numerical differentiation, The Cubic Spline method, Maximum and minimum values of a tabulated function, Numerical integration, Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Gaussian integration, and Numerical calculation for Fourier integrals.

Unit 3: Interpolation (9 Hours)

Introduction, Errors in polynomial interpolation, Finite differences, Detection of errors by use of difference tables, Newton's formulae for interpolation, Gauss central difference formulae for interpolation, Stirling's, Bessel's, and Everett's formulae for interpolation, Spline interpolation, and Cubic Splines.

Unit 4: Tensor Analysis (9 Hours)

Introduction, Contravariant and Covariant vectors, Second order and Higher order tensors, Addition, Subtraction, and Multiplication of tensors, Conjugate symmetric tensors of the second order, Fundamental tensor and Associate tensor, Permutation tensors, Cartesian tensors, and Isotropic tensors.

Unit 5: Differential Equations (10 Hours)

Ordinary differential equations (ODE), Basic concepts and modeling, Separable ODEs and modeling, Exact ODEs, Integrating factors, Linear ODEs, Bernoulli equation, Homogeneous linear ODEs of second order, Non-homogeneous linear ODEs of second order, Modeling for free oscillations (mass spring system), forced oscillations, resonance, and electrical circuits.

References:

1. Introductory methods of Numerical Analysis, Fourth Edition, S. S. Sastry, Pretice Hall of India Private limited, 2006.

2. Tensor Calculus - A concise course, First Edition, Barry Spain, Dover Publications, INC, New York, 2003.

3. Advanced Engineering Mathematics, Ninth Edition, Erwin Kreyszig, John Wiley Sons, INC, 2006.

24PH710E
Nanoscience and Nanotechnology

Unit 1: Fundamentals of Nanoscience and Technology (9 Hours)

Introduction and emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in nanotechnology: Introduction to Quantum wells, Quantum wires, and Quantum dots; Physical, Electrical, Mechanical, and other properties of Nanomaterials.

Unit 2: Synthesis of Nanomaterials (9 Hours)

Critical issues for nanostructure synthesis and strategies. Ball Milling, Sonication, Low-temperature Combustion Synthesis (LCS) method, Chemical Vapor Deposition (CVD) technique, Hydrothermal / Solvothermal Synthesis, Sol-gel Method.

Unit 3: Characterization of Nanomaterials (9 Hours)

Introduction, Structural characterization, Surface morphology, structure, particle size, and distribution using Scanning Electron Microscopy, Transmission Electron Microscopy, X-ray Diffraction, Atomic Force Microscopy, UV-visible spectroscopy, Fourier Transform Infra-Red Spectroscopy, Energy Dispersive X-ray Spectroscopy (EDS).

Unit 4: Fabrication of Nanomaterials (9 Hours)

Top-Down Approach - Planetary ball milling; Bottom-up approach (Wet chemical synthesis method), Aerosol synthesis, Spray pyrolysis, Electrochemical deposition, Gas phase production Methods: Physical and Chemical Vapor Deposition techniques.

Unit 5: Applications of Nanotechnology in Various Fields (9 Hours)

Medicine, Biology, Electronics and Communication systems, Optics, Agriculture, Renewable energy, Solar energy, Fuel cells, Solar cells, Batteries, Defence, Aerospace, Sporting goods, and fabric.

References:

1. Charles P. Poole Jr. and Frank J. Owens, *Introduction to Nanotechnology*, John Wiley Sons, 2006.

2. Guozhong Cao, *Nanostructures and Nanomaterials, Synthesis, Properties, and Applications*, Imperial College Press.

3. T. Pradeep, *NANO: The Essentials, Understanding Nanoscience and Nanotechnology*, Tata McGraw-Hill Publishing, 2007.
4. A.K. Bandyopadhyay, *Nano Materials*, New Age International Publications, 2014.
5. P.K. Palanisamy, *Applied Physics*, Scitech Publications (India), 2014.
6. M.N. Avadhanulu and P.G. Kshirsagar, *Engineering Physics*, S. Chand Publications, Revised Edition, 2014.
7. M.R. Srinivasan, *Engineering Physics*, New Age International Publications, 2014.
8. Bharat Bhushan, *Springer Handbook of Nanotechnology*, Springer, 2004.
9. A.S. Edelstein, *Nanomaterials: Synthesis, Properties, and Applications.*
10. Carl C. Koch, *Nanostructured Materials: Processing, Properties, and Applications.*
11. Dawn Bonnell, *Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications*, 2000.
12. Julian Chen, *Introduction to Scanning Tunneling Microscopy*, Monographs on the Physics and Chemistry of Materials.

POOL II — COURSES SYLLABUS

24PH720A
Functional Nanomaterials

Unit I: Nanostructured Materials (9 hours)

Bottom-up approaches: PVD, CVD, Laser ablation, Sol-gel process, Wet chemical synthesis, Physical and chemical self-assembly.

Top-Down approaches: Mechanical alloying, Nanolithography, Importance of Nanomaterials in various fields, Nanostructures, CNT-based sensors, Nanoparticles, Gold nanoparticles, Magnetic nanoparticles.

Unit II: Electronic, Electric and Optical Behavior of Materials (9 hours)

Metals, Insulators and Semiconductors, Electronic band theory of Solids: metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the band gap, temperature dependence of conductivity, carrier density and carrier mobility in semiconductors, optoelectronic devices: Photodiode, LED, LCD, Solar cells.

Unit III: Ionic Conductor (9 hours)

Introduction to ionic conductors, Types of Ionic conductors, Mechanism of ionic conduction, applications of ionic conductors.

a) Superconductivity: superconductivity in metals, alloys and ceramics materials (mixed oxides) BCS theory, Meissner effect, Type I & II superconductors, Applications of superconductors.

b) Dielectric polarization: Piezoelectricity and Ferro electricity.

Unit IV: Functional Nanocomposites (9 hours)

Classification of nanocomposites, Applications of nanocomposites; Optoelectronic devices, Electrochemical energy storage and electro-catalysis magnetic applications. Characterization of metal nanoparticles: TEM, STM, SEM, AFM and XRD.

Unit V: Potential Applications of Nanotechnology (9 hours)

Nano solar cells, Perovskite solar cells, fuel cells, Biological applications, Optical applications, Energy storage applications, Batteries, Aerospace, Marine, Coolants and Lubricants, Sensors, Fuel cells.

References

1. Charles P. Poole Jr. & Frank J. Owens, *Introduction to Nanotechnology*, John Wiley & Sons Inc., 2006.

2. Guozhong Cao, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press.

3. T. Pradeep, *NANO: The Essentials, Understanding Nanoscience and Nanotechnology*, Tata McGraw-Hill Publishing Company Limited, 2007.

4. A.K. Bandyopadhyay, *Nano Materials*, New Age International Publications, 2014.

5. P.K. Palanisamy, *Applied Physics*, Scitech Publications (INDIA) Pvt. Ltd., October Edition, 2014.

6. M.N. Avadhanulu & P.G. Kshirsagar, *Engineering Physics*, S. Chand Publications, Revised Edition, 2014.

7. M.R. Srinivasan, *Engineering Physics*, New Age International Publications, 2014.

8. A.S. Edelstein, *Nanomaterials: Synthesis, Properties and Applications*.

9. Carl C. Koch, *Nanostructured Materials: Processing, Properties and Applications*.

10. Dawn Bonnel, *Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications*, 2000.

24PH720B
Glass Properties

Unit 1: Density and Thermal Expansion (09 hours)

Introduction, Terminology, Measurement Techniques, Density, Thermal Expansion Coefficients, Density and Molar Volume, Compositional Effects, Thermal History Effects, Radiation Effects, Pressure Compaction, Thermal Expansion Behavior, Fundamentals of Thermal Expansion Behavior, Compositional Effects on Thermal Expansion Coefficients of Homogeneous Glasses, Phase Separated Glasses, Thermal History Effects, Effect of Crystallization.

Unit 2: Transport Properties (09 hours)

Introduction, Fundamentals of Diffusion, Ionic Diffusion, Ion Exchange, Ionic Conductivity, Compositional Effects, Activation Energy for Electrical Conductivity, Effect of Phase Separation on Electrical Conductivity, Effect of Thermal History on Electrical Conductivity, Effect of Crystallization on Electrical Conductivity, Chemical Durability, Weathering, Gas Permeation and Diffusion, Diffusion-Controlled Reactions.

Unit 3: Mechanical Properties (09 hours)

Introduction, Elastic Modulus, Hardness, Fracture Strength, Theoretical Strength of Glasses, Practical Strengths of Glasses, Flaw Sources and Removal, Strengthening of Glass, Statistical Nature of Fracture of Glass, Fatigue of Glasses, Thermal Shock, Annealing of Thermal Stresses.

Unit 4: Optical Properties (09 hours)

Introduction, Bulk Optical Properties, Refractive Index, Molar and Ionic Refractivity, Dispersion, Ultraviolet Absorption, Visible Absorption, Amber Glass, Colloidal Metal Colors, Colloidal Semi-Conductor Colors, Radiation-Induced Colors, Solarization, Infrared Absorption, Infrared Absorption by Bound Hydrogen Species, Infrared Absorption by Dissolved Gases, Infrared Cutoffs or the Ultraviolet Edge.

Unit 5: Thermal Analysis of Glasses (09 hours)

Introduction, Differential Scanning Calorimeters, Glass Transformation Temperature, Fictive Temperatures, Specific Heat Measurements, Crystallization, Isothermal Crystallization Rates, Dynamic (Non-Isothermal) Crystallization Rates, Pseudo-Nucleation Rate Curves, Independent Determination of Avrami Parameter, Viscosity.

Reference Text Book:

Shelby, James E. *Introduction to Glass Science and Technology*, Royal Society of Chemistry, 2020.

24PH720C
Liquid Crystals-II

Unit I: Thermodynamic Properties and Phase Transitions (09 hours)

Theory of phase transitions - Pre-transitional phenomena - Calorimetric measurements - Molar heat - Transition entropy and Enthalpy.

Unit II: Optical Properties of Liquid Crystals (09 hours)

Optical properties - Birefringence - Rayleigh's Scattering - UV and visible absorption spectroscopy - IR spectroscopy.

Unit III: Liquid Crystal Displays (LCDs) and Electro-Optic Phenomena (09 hours)

Liquid Crystal Displays - Electro-optic phenomena - Field Induced Birefringence - Twisted Nematic - Guest Host Effect - Cholesteric to Nematic Transition - Storage Mode - Display Life - Alignment of Liquid Crystal - Homogeneous and Homeotropic.

Unit IV: Technical Applications of Liquid Crystals (09 hours)

Technical Applications - Thermography - Electro-optic Display Devices - Holography - Interferometry and Other Applications.

Unit V: Electro-Optic Modulators and Switching Mechanisms (09 hours)

Electro-optic Modulators with Liquid Crystals - Ferroelectricity in Smectic Liquid Crystals - Surface Stabilized Switching Mechanism in Liquid Crystals - Polarization Switching - Threshold Less Switching - V-Shaped Switching.

References:

1. *The Physics of Liquid Crystals* by P.G. de Gennes, Ed: Marshall and Wilkinson, Clarendon Press, Oxford, U.K.
2. *Introduction to Liquid Crystals* by E.P. Raynes, Plenum Press.
3. *Liquid Crystals* by S. Chandrasekhar, Cambridge Univ. Press.
4. *The Molecular Physics of Liquid Crystals* by G.W. Luckhurst and G.W. Gray, Academic Press, New York, U.S.A.
5. *Hand Book of Liquid Crystals* by Kato, Ed: D. Demus, J. Goodby, G.W. Gray, H.W. Spiess, and V. Vill, (Weinheim: Wiley-VCH), 1998.
6. *Thermotropic Liquid Crystals - Recent Advances* Ed: A. Ramamoorthy, Springer Press.
7. *Alignment Technology and Applications of Liquid Crystal Devices* by Kohki Takatoh, Masaki Hasegawa et al., Taylor & Francis Press.
8. *Ferroelectric Liquid Crystals - Principles, Properties and Applications* by J.W. Goodby, R. Blink, N.A. Clark, S.T. Lagerwall et al.
9. *Ferroelectric Liquid Crystals* by B. Zeks and R. Blink, Gordon & Breach.
10. H. Kihara, T. Kato, T. Uryu, S. Ujiie, U. Kumar, J.M.J. Frechet, D.W. Bruce, and D.J. Price, *Liq. Cryst.*, 21, (1996) 25; Z. Siderotou, D. Tsiourvas, C.M. Paleos, and A. Skoulios, *Liq. Cryst.*, 22, (1997) 51; C.M. Paleos and D. Tsiourvas, *Liq. Cryst.*, 28, (2001) 1127.
11. T.C. Lubensky and L. Radzihovsky, *Phy. Rev. E.*, 66, (2002) 031704.

24PH720D
Materials Characterization Techniques

Unit 1: Structural Analysis (9 hours)

Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction.

Unit 2: Microstructural Analysis (9 hours)

Optical Microscopy, Interaction of electrons with solids, Scanning Electron Microscopy, Transmission Electron Microscopy and specimen preparation techniques, Scanning Transmission Electron Microscopy, Energy Dispersive Spectroscopy, Wavelength Dispersive Spectroscopy.

Unit 3: Optical Spectroscopy (9 hours)

Introduction to Spectroscopy, Electromagnetic Spectrum, UV-Vis-NIR Spectroscopy, Fluorescence Spectroscopy, Fourier Transform Infrared Spectroscopy, Raman Spectroscopy.

Unit 4: Thermal Analysis (9 hours)

Thermo-gravimetric analysis, Differential Thermal Analysis, Differential Scanning Calorimetry, Thermomechanical analysis, and Dilatometry.

Unit 5: Electrical and Magnetic Measurements (9 hours)

Van der Pauw method, Four Probe Method, Hall Effect, Magnetoresistance, Thermoelectric Power, and Photoconductivity Measurements; Vibrating Sample Magnetometer, SQUID.

References:

1. Li, Lin, Ashok Kumar, *Materials Characterization Techniques*, Sam Zhang: CRC Press (2008).

2. Cullity, B.D., and Stock, R.S., *Elements of X-Ray Diffraction*, Prentice-Hall (2001).

3. Murphy, Douglas B., *Fundamentals of Light Microscopy and Electronic Imaging*, Wiley-Liss Inc., USA (2001).

4. Yagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., *Advanced Techniques for Materials Characterization, Materials Science Foundations (Monograph Series)*, Volumes 49–51, (2009).

5. Ewald, W.W., *Thermal Analysis*, John Wiley & Sons (1986).

6. Achtman, J.B., Kalman, Z.H., *Characterization of Materials*, Butterworth-Heinemann (1993).

7. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle Jr., *Instrumental Methods of Analysis*, 7th Edition, CBS Publications (1988).

24PH720E
Physics of Advanced Materials

UNIT – 1
Dielectrics (9 hours)

Polarization and dielectric constant, Frequency dependence of the electronic polarizability, Complex dielectric constant of non-polar dielectrics, Dipolar relaxation, Dielectric losses, Dielectric measurements at low field and high field, Aging, Classification of piezoelectric, pyroelectric, and ferroelectric crystals.

UNIT – 2: Ferroelectrics (9 hours)

Ferroelectricity, Ferroelectric domains, and antiferroelectricity. Types of materials - Perovskite, Aurivillius, Tungsten Bronze, and Pyrochlores. Applications of ferroelectrics, Relaxor ferroelectrics, Ferroelectric memory devices – DRAM and Non-volatile memory.

UNIT – 3: Piezoelectrics (8 hours)

Piezoelectric materials and properties, Piezoelectric coupling factor, Resonance method for piezoelectric measurement, Piezoelectric sensors, Ultrasonic transducers, Piezoelectric transformers, and Piezoelectric actuators.

UNIT – 4: Magnetic Materials (10 hours)

Classification, Atomic origin of magnetism, Origin of permanent magnetic moments, Ferromagnetism and exchange field, Saturation magnetization at absolute zero, Temperature dependence of spontaneous magnetization, Ferromagnetic domains and domain theory, Antiferromagnetism, Ferrimagnetism, Ferrites, and Multiferroics.

UNIT – 5: Spintronics (9 hours)

Introduction, Comparative merits and demerits of spintronics, Research efforts on spintronics, Quantum mechanics of spin, Dynamics of magnetic moments, Spin-dependent band gap in ferromagnetic materials, Functionality of 'spin' in spintronics, Different branches of spintronics, and Applications of spintronics.

References

1. Dekker, A.J., *Electrical Engineering Materials.* First Edition, Prentice Hall India Pvt. Ltd., 1959.

2. Jaffe, B., Cook, W.R., Jaffe, H., *The Piezoelectric Effect in Ceramics.* First Edition, Piezoelectric Ceramics, 1971, pp. 7–21.

3. Wahab, M.A., *Solid State Physics: Structure and Properties of Materials.* Fifth Edition, Narosa Publishers, 2006.

4. Kittel, C., *Introduction to Solid State Physics.* Fourth Edition, 2021.

5. Pardo, L., Ricote, J., Galassi, C., *Advances in Processing of Bulk Ferroelectric Materials*, Multifunctional Polycrystalline Ferroelectric Materials: Processing and Properties, 2011, pp. 1–37.

6. Uchino, K., *Ferroelectric Devices.* CRC Press, 2018.

7. Dey, P., Roy, J.N., *An Overview of Spintronics.* Spintronics: Fundamentals and Applications, 2021, pp. 1–22.