Koneru Lakshmaiah Education Foundation
(Deemed to be University estd. u/s. 3 of the UGC Act, 1956)
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List of Pre-PhD Courses for the A.Y:2025-26

DEPARTMENT OF PHYSICS

S.No	Paper 1	Course Code
1	RESEARCH METHODOLOGY	25RES102

S.NO	PAPER–2	Course Code (LTPS)	PAPER – 3	Course Code (LTPS)
1.	Spectroscopic Studies on Transition Metal Ions	25PHY201 (4-0-0-0)	Spectroscopic Studies on Rare Earth Ions	25PHY301 (4-0-0-0)
2.	Nanoscience and Technology	25PHY202 (4-0-0-0)	Solid State Ionics	25PHY302 (4-0-0-0)
3.	Remote Sensing & Geospatial Analysis	25PHY203 (4-0-0-0)	Upper Atmospheric Science	25PHY303 (4-0-0-0)
4.	Nuclear Physics-I	25PHY204 (4-0-0-0)	Nuclear Physics - II	25PHY304 (4-0-0-0)
5.	Liquid Crystals-I	25PHY205 (4-0-0-0)	Liquid Crystals-II	25PHY305 (4-0-0-0)
6.	Physics of Solar Engineering	25PHY206 (4-0-0-0)	Advanced Solar Energy Storage Technologies	25PHY306 (4-0-0-0)
7.	Particle Physics-I	25PHY207 (4-0-0-0)	Aeronomy	25PHY307 (4-0-0-0)
8.	Phosphors for Lighting Applications	25PHY208 (4-0-0-0)	Thin Film Technology and Applications	25PHY308 (4-0-0-0)
9.	Synthesis and Characterization of Materials	25PHY209 (4-0-0-0)	Particle Physics-II	25PHY309 (4-0-0-0)

RESEARCH METHODOLOGY **Code: [25 RES 102]**

[COMMON TO ALL NON-ENGINEERING STREAMS]

Unit I

Introduction to Research Methodology: The philosophy, objectives, scope, and significance of research across disciplines, differentiating qualitative and quantitative approaches. Includes research methods vs. methodology, nature of inquiry in various fields, qualities and ethics of a researcher, identification and formulation of research problems, literature review techniques, and formats for thesis, dissertations, and research publications, with use of referencing systems and digital resources.

Unit II

Research Design, Measurement, and Sampling: Types and features of research design, including experimental designs, measurement scales, and attitude measurement methods. Explains census vs. sample surveys, sampling steps, probability and non-probability methods, and criteria for good sample design, along with random sampling techniques.

Unit III

Data Collection and Analysis: Primary and secondary data sources, methods of data collection, and data processing steps. Covers descriptive statistics, correlation and regression, multivariate methods, fundamentals of time series and spectral analysis, error analysis, and goodness of fit, with applications of statistical software (SPSS/R/Python).

Unit IV

Hypothesis Testing and Advanced Statistical Methods: Hypothesis formulation and testing using parametric and non-parametric tests, significance testing for various measures, association of attributes, advanced probability distributions, and Bayesian inference, with applications across sciences, mathematics, social sciences, and humanities.

Unit V

Interpretation, Reporting, and Applications of Research: Interpretation techniques, precautions, report writing, thesis layout, academic writing style, patent procedures, and presentation skills. Discusses the application of research in sciences, social sciences, humanities, management, law, mathematics, and pharmacy, including modelling, simulation, decision support, and computational analysis.

Text Books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.

Reference Books:

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.

25PHY201 – Spectroscopic Studies on Transition Metal Ions

UNIT- I: Introduction

The concept of ligand field - The scope of ligand field theory – The 'd' and other orbitals. The physical properties affected by ligand fields.

UNIT- II: Quantitative basis Of Crystal fields

Crystal field theory – The octahedral crystal field potential on the 'd' wave function – The evaluation of 10 Dq – The tetrahedral potential.

UNIT- III: Free Ion in Weak, Medium, And Strong Crystal fields

The effect of a cubic crystal field on S and P terms – on D terms – on F terms – on G, H and I terms – Strong field configurations – Transition from weak to strong crystal fields –
term energy level diagrams – Tanabe-Sugano diagrams.

UNIT- IV: Basic theory of g-Factor

The g-factor – the general Hamiltonian – The crystal field and orbital symmetry – Symmetry of p and d orbitals – Effect of crystal field – Jahn-Teller distortion and Kramer's theorem – Magnitude of the crystal field – Calculation of g-factors – Ti^{3+} in octahedral field, Weak crystal field: Ce^{3+} ion, Strong field: Cu^{3+} ion and free radicals. The spin-Hamiltonian – effect of field orientation – Fine structure – Zero-field splitting, The Spin-Hamiltonian for V^{3+} and S-state ions-Mn^{2+} ion.

UNIT-V: Nuclear Hyperfine Structure

Introduction – General treatment – Isotropic hyperfine interaction – The spin-Hamiltonian energy levels – Interpretation of isotropic hyperfine coupling constant – Unpaired spin density – Anisotropic hyperfine interaction – The Spin-Hamiltonian energy levels – Interpretation of anisotropic hyperfine coupling constants – the term <(1 – 3 Cos2 / r3)>av, Second order effects: second order effects on radicals in solutions and in oriented radicals, Nuclear quadrupole interactions.

TEXTBOOKS:

1. Introduction to Ligand Field, B.N.Figgis, Wiley – Eastern Ltd., New Delhi (1976).
2. Electron Spin Resonance in Chemistry, Peter B.Ayscough. Methuen and Co.Ltd., London (1964).
3. Instrumental Methods and Analysis, H.Willard, L.Merritt, J.Dean,F.Settle, CBS publishers and distributors (1986).
4. Fundamentals of Molecular Spectroscopy, C.N.Banwell, Tata-McGraw-Hill publishing company Ltd, New Delhi (1990).

25PHY301 – Spectroscopic Studies on Rare Earth Ions

Unit – I: Atomic Spectroscopy

The free ion: Free ion terms for d2 and f2 configurations; Spin-orbit coupling; Ground states for fn configurations; Coulomb and spin-orbit energies; Intermediate coupling.

Unit – II: Absorption Characteristics of Rare Earth ions

Intra-configurational f-f transitions; magnetic dipole, electric dipole and induced electric dipole transitions; Intensity of absorption bands; Judd-Ofelt theory for induced electric dipole transitions and evaluation of Judd-Ofelt parameters.

Unit – III: Luminescence characteristics of Rare Earth ions

Radiative transition rates, Emission cross-sections and Branching ratios, relaxation process: Non-radiative relaxation: Multi-phonon, Radiative quantum efficiencies of rare earth ion energy levels.

Unit – IV: Energy Transfer in Rare earths

Possible mechanisms of energy transfer: Resonance energy transfer; Process of IR to Visible up-conversion; Energy transfer from lanthanides to other species.

Unit – V: Rare Earth Doped lasers

Principle of laser action: typical rare earth lasers- Nd: YAG: Energy level diagram of Nd(III) ion in YAG laser, Liquid rare earth lasers, Lasers from vapors of rare earth compounds and Progress in the development of Lasers.

Textbooks:

1. Introduction to Ligand Fields.
B N Figgis, Wiely Eastern Ltd, New Delhi. John Wiley & Sons Inc,1966

Reference Books:

1. Optical Spectra of Transparent Rare Earth Compounds. S Hufner, Academic Press, London, 1978.
2. Lasers and excited states of Rare Earths.
R Reisfield and C K Jorgensen, Springer-Verlag, New York,1977.

25PHY202 – Nanoscience and Technology

Unit - I: Introduction: Importance of Nano science & technology, Emergence of Nanotechnology, Types of Nano materials, Bottom-up and Top-down approaches,, Applications of Nano Technology in Science and technology.

Unit - II:

Zero Dimensional Nanostructures: Nano particles through homogenous nucleation; Growth of nuclei, synthesis of metallic nano particles, Nano particles through heterogeneous nucleation; Fundamentals of heterogeneous nucleation and synthesis of nano particles using micro emulsions and Aerosol.

Unit – III:

One Dimensional Nanostructure, Nano wires and nano rods: Spontaneous growth: Evaporation and condensation growth, Casting method, vapor-liquid-solid growth, Electrochemical deposition and Electro spinning.

Unit – IV:

Two dimensional nanostructures: Fundamentals of film growth. Physical vapour Depostion(PVD): Chemical Vapour Depostion (CVD) Characterization of nano materials by using spectroscopic and microscopic techniques-XRD, FTIR, DSC, SEM and TEM. Electrical measurements of nano composite materials by using four probe methods.

Unit – V:

Introduction to Carbon Nano Tubes (CNTs), Properties, Preparation of CNTs-Laser ablation method, Arc method, chemical vapor deposition (CVD), Sol-Gel method, Carbon nanotube Polymer Nano composites, Applications of Nano in drug delivery system.

Textbooks:

1. Introduction to Nano technology by Charles P.Poole. Jr.& Frank J.ownes Johnwielly & sons Inc. Publishers-2006
2. Nano structures and Nano materials: Synthesis, properties and applications Guozhong Cao-Imperial College press.

25PHY302 – Solid State Ionics

UNIT- I: Introduction Classification of solids:
Crystalline, amorphous materials, Defects and Transport in Crystalline Solids, structural characterization by IR, XRD, DSC/TGA and SEM methods

UNIT- II: Ionic Materials:
Introduction to polymeric materials, Blends, Composites and polymer electrolytes, Solid conducting polymer electrolytes – Fast ion conductors, Characterization. Solid conducting polymer electrolytes composites – Synthesis, processing and characterization and their device applications – Electrochemical cells, Rechargeable polymer battery, electro chromic devices, electro chemical solar cells, sensors.

UNIT- III: Nano materials:
Introduction to nano particles and nano composites, synthesis and processing technologies for nanostructure materials – Chemical co-precipitation method, sol-gel method, hydrothermal method, Mechanical, optical and electrical studies of nano composites conductivity and electrical transport properties of processable nanomaterials–Nanoelectronics and Nanosensors, Industrial Nanotechnology, Applications.

UNIT- IV: Electrochemical cell Devices:
Introduction to Electro chemical cells, sensors and fuel cells – Types– Synthesis and development of solid electrolyte membranes, Supercapacitors – Characterization by XRD, Differential scanning calorimetry (DSC), SEM (Scanning Electron Microscopy)

UNIT- V: Measurements:
Measurement of electrical conductivity of solid electrolyte membranes – Determination of transference number by Wagner's polarization method, water balance in membranes Fabrication and working principles of Electro chemical cell, fuel cell, sensors– Calculation of open circuit voltage (OCV), short circuit current, resistivity, current density, power density and estimation of efficiency, V-I characteristics of fuel cells, Application of fuel cells in transportation and low temperature electronic devices .

Textbooks:
1. Solid state Ionics for Batteries by M. Tatsumisago, M. Wakihara etc., Springer Publisher, 2005.
2. Solid state Ionics by B.V.R. Chowdary, Wenji.B. World Scientifics Ltd.

Reference Books:
1. Defects and Transport in Crystalline Solids, Kofstad P., Norby T., 1st edition, 2007.

25PHY203 – Remote Sensing & Geospatial Analysis

UNIT-I: Introduction to Remote Sensing and Applications

Definition – SONAR; Satellite Images Vs Maps; Remote Sensing Vs GIS; Remote Sensing Vs Aerial Photography / Photogrammetry; Remote Sensing Vs SONAR; Spatial data acquisition ground based and remote sensing methods; Applications of remote sensing-Agriculture, Forestry, Geology, Hydrology, Sea Ice, Land Cover & Land Use, Mapping, Oceans & Coastal Monitoring.

UNIT-II: Electromagnetic Radiation

Electromagnetic spectrum and energy; Interaction mechanisms; Laws regarding the amount of energy radiated from an object; Planck Radiation Law; Wien's displacement law; Black body concept; Emissivity and Radiant Temperature; Wavelength bands; Atmosphere effects; Scattering and Absorption; Reflectance spectra; Mixtures and Grain Size Effects; Continuum and Band Depth; Continuum-Removed Spectral Feature Comparison; Viewing Geometry.

UNIT-III: Sensors and Platforms

Introduction to sensors; Sensor types – passive sensors, active sensors; Radar characteristics; principles of imaging radar; geometric properties of radar; data formats; distortions in radar images; interpretation of radar images; applications of radar; Airborne remote sensing; Space borne remote sensing; Image data characteristics; Data selection criteria. Integration of AI/ML in Remote Sensing – Overview of AI/ML role of AI/ML in image interpretation, object detection, classification, and prediction.

UNIT-IV: Radio Metric Corrections

Introduction, From satellite to ground radiances: atmospheric correction, Atmospheric correction in the visible part of the spectrum – cosmetic corrections, relative AC methods based on ground reflectance, Absolute AC methods based on atmospheric processes.

UNIT-V: Thermal Remote Sensing

Introduction, principles of thermal remote sensing- physical laws, blackbodies and emissivity, Radiant and kinetic temperatures, Processing of thermal data – band ratios and transformations, determining kinetic surface temperatures, Thermal applications – rock emissivity mapping, thermal hot spot detection.

Textbooks

1. Campbell, J.B., and Wynne, R.H. Introduction to Remote Sensing (5th Edition). Guilford Press, 2011. ISBN: 978-1609181765.
2. Lillesand, T.M., Kiefer, R.W., and Chipman, J.W.Remote Sensing and Image Interpretation (7th Edition). Wiley, 2015. ISBN: 978-1118343289.
3. Gonzalez, R.C., and Woods, R.E. Digital Image Processing (4th Edition). Pearson, 2018. ISBN: 978-0133356724.

Reference Books

1. Nichol, J., and Wong, M.S.Thermal Remote Sensing of Urban and Natural Environments. CRC Press, 2017. ISBN: 978-1138892841.
2. Richards, J.A., and Jia, X.Remote Sensing Digital Image Analysis (5th Edition). Springer, 2020. ISBN: 978-3662603223.

25PHY303 – Upper Atmospheric Science

UNIT I: Introduction

Survey of atmosphere, Physical properties of the upper atmosphere – atmospheric composition, atmospheric dynamics, atmospheric energetic, atmospheric layers and relation to temperature.

UNIT II: Earth System

Interaction of energetic solar photons with the upper atmosphere, History of Climate and the Earth System, Components of the Earth System, Hydrologic & carbon cycles, Solar irradiance, optical depth, Photo-ionization, photo dissociation, photoelectrons, Remote sensing of atmospheric composition from space, Role of atmosphere in global climate feedback.

UNIT III: Atmospheric Thermodynamics

Gas Laws, Hydrostatic Equation, First Law of Thermodynamics, Adiabatic Processes, Water Vapor in Air, Static Stability, Second Law of Thermodynamics and Entropy, Energy transfer by conduction, convection, and radiation in upper layers, Gravity waves and their thermodynamic effects in the upper atmosphere.

UNIT IV: Radiative Transfer

Spectrum of Radiation, Quantitative Description of Radiation, Blackbody Radiation, Physics of Scattering and Absorption and Emission, Radiative Transfer in Planetary Atmospheres, Radiation Balance at the Top of the Atmosphere, Impact of greenhouse gases on the thermosphere.

UNIT V: Atmospheric Chemistry

Composition of Troposphere Air, Sources, Transport, and Sinks of Trace Gases, Some Important Troposphere Trace Gases, Troposphere Aerosols, Air Pollution, Troposphere Chemical Cycles, Stratospheric Chemistry, Ozone chemistry in the stratosphere.

Text Books

1. Wallace, J.M., and Hobbs, P.V.Atmospheric Science: An Introductory Survey (2nd Edition). Academic Press, 2006.ISBN: 978-0127329512.
2. Andrews, D.G.An Introduction to Atmospheric Physics (2nd Edition). Cambridge University Press, 2010.ISBN: 978-0521693189.
3. Houghton, J.T.The Physics of Atmospheres (3rd Edition). Cambridge University Press, 2002. ISBN: 978-0521011228.

Reference Book

1. Lary, D.J.Artificial Intelligence and Climate Science. Springer, 2021.ISBN: 978-3030658756.
2. Physics and chemistry of the Upper atmosphere ByM.H.Rees, CRC Press, 2003.sss

25PHY204 – Nuclear Physics-I

UNIT – I:

Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion.

UNIT – II:

Two nucleon problem, Elementary ideas of alpha, beta and gamma decays and their selection rules; Nuclear Forces: Characteristics of nuclear forces – Ground state of Deuteron – Proton – Proton scattering – Neutron – Proton scattering – Meson theory of nuclear forces.

UNIT – III:

Nuclear Models: Introduction – The liquid drop model – Bethe-Weizacker semi-empirical binding energy equation and its applications – Nuclear shell model – Shell Model: Single particle model with square well, harmonic oscillator and spin-orbit potentials, Collective model, Nilsson model. Energy levels and calculation of angular momentum – Collective model.

UNIT –IV:

Nuclear Reactions: Types of nuclear reactions – Compound nuclear reactions – Nuclear cross section – Resonance theory – Briet Wigner formula.

UNIT – V:

Nuclear interactions: Direct and compound nuclear reaction mechanisms- cross sections in terms of partial wave amplitudes–compound nucleus–Scattering Matrix–Reciprocity theorem–Breit- Wigner one – level formula- Resonance scattering.

Textbooks

1. Concepts of Nuclear Physics, B. L. Cohen (Tata McGrawHill), 2001.
2. Nuclear Physics - An Introduction, S. B. Patel., Springer, 2006.
3. Subatomic Physics, Frauenfelder and Hanley(Prentice-Hall), 2001.
4. Nuclear Physics, I.Kaplan, 2001.
5. Nuclear Radiation Detectors, S. S. Kapoor, V. S.Ramamurthy. Tata Mc Graw Hill, 2008

25PHY304 – Nuclear Physics-II

Unit – I:

Nuclear Decays: Nuclear transformations – Radioactive decay – Alpha decay – Gamow‟s theory – Beta decay – Fermi theory –Selection rules – Interaction of gamma radiation with matter – Photo electric effect; – Compton scattering – Pair production.

UNIT – II:

Nuclear Accelerators: Introduction – Linear accelerators – Drift tube and Wave guide accelerators – Low energy circular accelerators – Cyclotron and Betatron – High energy circular accelerators – Synchrotron and Microtron

UNIT – III:

Nuclear Reactors: Nuclear fission and fusion reactions – Nuclear chain reactions – Four factor formula – The critical size of a reactor – General aspects of reactor design – Classification of reactors – Power reactors (elementary aspects only)

UNIT – IV:

Nuclear Structure: Problem of Nucleon Nucleon Interactions and Nuclear Forces, Nuclear Models and Nuclear Matter, Electromagnetic and Weak Interactions.

UNIT – V:

Experimental methods: Gamma-ray spectroscopy, conversion-electron and charged-particle spectroscopy associated with nuclear reactions and Coulomb excitation, Compton-suppressed Ge detectors, multiplicity filter, Neutron detectors, Sector field electron spectrometer, mini-range spectrometer, Recoll mass- separator, Advanced detector arrays-INGA, GAMMASPHERE and EUROBALL etc.

Textbooks

1. Concepts of Nuclear Physics, B. L. Cohen (Tata McGrawHill), 2001.
2. Nuclear Physics - An Introduction, S. B. Patel., Springer, 2006.
3. Subatomic Physics, Frauenfelder and Hanley(Prentice-Hall), 2001.
4. Nuclear Physics, I.Kaplan, 2001.
5. Nuclear Radiation Detectors, S. S. Kapoor, V. S.Ramamurthy. Tata Mc Graw Hill, 2008.

25PHY205 – Liquid Crystals-I

UNIT – I: Thermodynamic Properties

Theories of phase transitions-pre transitional phenomena – Calorimetric measurements – Molar heat – Transitional entropy and enthalpy.

Influence of molecular structure on thermal behaviour.

UNIT – II: Optical Properties

Birefringence –Rayleigh's scattering – UV and Visible absorption spectroscopy.

Temperature dependence of optical transitions.

UNIT – III: Liquid Crystal Displays

Electro optic phenomena – Field induced birefringence – Twisted nematic – Guest – Host effect – Cholestrics to nematic trasition – Storage mode – Display life – Alignment of liquid crystal, homogeneous and homeotropic.

Lifespan and degradation mechanisms in display devices.

UNIT – IV: Emerging Applications

Thermography – Elecro optic display devices – Holography – Interferometry. Emerging applications: sensors, tunablephotonic devices.

UNIT – V: Twist Grain Boundary Phases

The TGBA Phase, Textures of planar anchoring conditions, hometropic anchoring conditions, Suppression of TGBA texture, TGBC and TGBCA phases. Chirality, frustration, and defect structures in TGB phases.

Textbooks

1. Introduction to Liquid Crystals — E. B. Priestley, P. J. Wojtowicz, P. Sheng — Plenum Press, New York — 1975.
2. Handbook of Liquid Crystals — Hans Kelker, Rolf Hatz, Christa Schumann — Verlag Chemie, Weinheim — 1980.

Reference Books

1. The Molecular Physics of Liquid Crystals — G. W. Gray — Academic Press, London — 1979.
2. Liquid Crystals — S. Chandrasekhar — Cambridge University Press — 1992 (2nd Edition).
3. Textures of Liquid Crystals — Ingo Dierking — Wiley-VCH, Weinheim — 2003.

25PHY206 – Physics of Solar Engineering

UNIT- I: Fundamentals of Solar Cells

Foundational Principles: Semiconductor Physics- Photovoltaic Effect - p-n Junctions - Solar Cell Parameters - Loss Mechanisms and Efficiency Limits. Solar Cell Technologies and Materials: First-Generation Solar Cells - Second-Generation Solar Cells - Third-Generation Solar Cells Advanced Topics and Characterization: Advanced Device Architectures - Characterization Techniques - Modeling and Simulation - Practical Applications and Systems.

UNIT- II: Core Foundations and Theoretical Analysis

Ordinary Differential Equations: One-Step Methods - Multi-Step Methods - Stiffness - Stability and Convergence - Error Analysis. Partial Differential Equations (PDEs): Classification of PDEs - Function Spaces - Banach and Hilbert spaces - Weak Formulation - Finite Element Method - Variational Principles - Taylor series expansions - Equivalence Theorem- Elliptic- Parabolic – Hyperbolic - Conservation properties - Galerkin Method - Element Formulations - Error Estimation: Céa's Lemma - Linear System Solvers - Nonlinear Equations - Computational Tools.

UNIT- III: Solar PV Technologies (qualitative)

Foundational Principles: Solar Spectrum - Photovoltaic Effect - Solar Cell Parameters - open-circuit voltage (Voc), short-circuit current (Jsc), and fill factor (FF) - Efficiency Limits - Shockley-Queisser limit, First- and Second-Generation Technologies: Crystalline Silicon (c-Si) - Thin-Film Solar Cells - Cadmium Telluride (CdTe) and Copper Indium Gallium Selenide (CIGS). Manufacturing and Cost. Third-Generation and Emerging Technologies: Perovskite Solar Cells - Organic and Dye-Sensitized Solar Cells (DSSC) - Multi-Junction and Tandem Solar Cells - Concentrated Photovoltaics (CPV) - Module and System Design - Energy Storage Integration - Environmental and Economic Impact:

UNIT- IV: High Efficiency Concepts in Solar Cells

Thermodynamics and Fundamental Limits: Shockley-Queisser Limit Revisited - Beyond the Shockley-Queisser Limit - hot carrier solar cells - multi-exciton generation (MEG) in quantum dots - Thermodynamics of Solar Energy Conversiony. Light Management and Advanced Device Architectures: Light Trapping - surface texturing- plasmonic nanoparticles-photonic crystals - Anti-Reflection Coatings -Heterojunctions and Interface Passivation - heterojunctions with intrinsic thin-layer (HIT) solar cells - Back-Contact Solar Cells - Interdigitated Back Contact (IBC) solar cells, Multi-Junction Solar Cells - tandem solar cells - Perovskite Solar Cells.

UNIT- V: Energy Levels and Spectra - Characteristics:

Quantum Mechanical Foundations: Advanced Quantum Mechanics - Angular Momentum - Symmetry and Group Theory. Atomic Spectra - Atomic Structure - Zeeman and Stark Effects - Radiative Transitions and Selection Rules - Molecular Spectra - Born-Oppenheimer Approximation - Rotational and Vibrational Spectra - Electronic Spectra and Franck-Condon Principle - Franck-Condon principle - Raman Spectroscopy- Lasers and Spectroscopic Techniques - Spectroscopic Characterization - Relativistic and Quantum Electrodynamics (QED) Effects - Computational Spectroscopy.

Textbooks:

1. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process - 4 th Edition (2013), John Wiley and Sons, New York, ISBN: 978-0-470-87366-3, Solar Energy Laboratory, University of Wisconsin-Madison, pp. 944.
2. M. Stix, The Sun, An Introduction, Second Edition, Springer 2002.
3. Jenny Nelson, The Physics of Solar Cells. Imperial College Press, 2003
4. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications (2011), 2nd edition, PHI Publications, pp. 512.
5. Sukhatme S.P. J K Nayak, Solar Energy, Tata McGraw Hills P Co., ISBN: 9789352607112, 4th Edition, 2017, pp. 568.
6. C. Julian Chen, Physics of Solar Energy (2011), ISBN: 978-1-118-04832-0, pp. 352.
7. K. Mertens, Photovoltaics: Fundametals, Technology and Practice, John Wiley & Sons Ltd (2014)
8. Handbook of Photovoltaic Science and Engineering 2nd Ed. , A. Luque, S. Hegedus (editors), John Wiley & Sons Ltd (2011)
9. A. Smets, K. Jager, O. Isabella, R. V. Swaaij, M. Zeman, Solar Energy: The physics and engineering of photovoltaic conversion, technologies and systems, UIT Cambridge Ltd. (2016).
10. S.R. Wenham, M. Green, M.E. Watt, R. Corkish, A. Sproul, Applied Photovoltaics ? 2nd Edition (2009)
11. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and applications, 3rd Edition, PHI Learning Pvt. Ltd. (2019).
12. Jenny Nelson, The Physics of Solar Cells, Imperial College Press (2003).
13. Peter Wurfel, Physics of solar cells: from principles to advanced concepts, 2nd Edition, WileyVCH (2009).

Reference Books:

1. Chemical Applications of Group Theory : F.A. Cotton.
2. Fundamentals of Molecular Spectroscopy : C.N. Banwell.
3. Introduction to Molecular Spectroscopy : G.M. Barrow.
4. Modern Spectroscopy : J.M. Hollas.
5. D. A. Neamen and D. Biswas, Semiconductor Physics and Devices
6. R.F. Pierret, Semiconductor Device Fundamentals
7. SM Sze and Kwok K Ng, Physics of semiconductor devices, third edition ,John Wiley & Sons (2007)

25PHY306 – Advanced Solar Energy Storage Technologies

UNIT- I: Solar Energy Storage

Foundational Principles: Solar PV Systems - Maximum Power Point Tracking-Thermodynamics of Energy Storage – Electrochemistry-Electrochemical Energy Storage-Lithium-Ion Batteries-Redox Flow Batteries -Solid-State Batteries. Thermal Energy Storage: Sensible and Latent Heat Storage - Phase Change Materials (PCMs)- hermochemical Storage - Mechanical and Chemical Storage -Pumped Hydro Storage - Hydrogen as an Energy Carrier - Hybrid Energy Systems - Grid Integration and Smart Grids - Modeling and Simulation - Economic and Policy Aspects.

UNIT- II: Solar Thermal Applications

Foundational Principles: Solar Radiation - Heat Transfer and Thermodynamics - Optics and Materials Science - design of solar selective coatings and anti-reflection coatings- Flat-Plate Collectors - Concentrating Solar Power (CSP) Systems - parabolic trough collectors, solar power towers - dish Stirling systems - Solar Thermal Energy Storage - sensible heat storage, latent heat storage - thermochemical storage- Industrial Process Heat (SHIP) - Solar Cooling and Desalination - absorption refrigeration cycles - Solar Passive Architecture - Modeling and Simulation - CFD.

UNIT- III: Solar Space Conditioning Systems

Solar Radiation and Optics - solar selective coatings - glazing materials Solar Thermal Collectors - flat-plate collectors - Heat Transfer and Fluid Dynamics - Solar Cooling Technologies - Absorption Refrigeration Cycles - lithium bromide-water - ammonia-water - Desiccant Cooling Systems - Adsorption Refrigeration - Thermal Energy Storage (TES) -Thermochemical storage - System Integration and Control -Building Simulation and Modeling - TRNSYS, EnergyPlus, MATLAB - Economics and Environmental Impact.

UNIT- IV: Other Solar Applications

Solar Thermal Desalination and Water Treatment: Fundamentals of Desalination - Solar Stills - design, performance, and modeling of various solar still - Humidification-Dehumidification (HDH) Systems - Membrane Distillation (MD) Solar Industrial Process Heat - Process Heat Analysis - Collector Integration - heat exchangers - Pinch Analysis - Case Studies: Solar Cooking and Drying - Solar Cooker Design - box cookers, parabolic cookers, and panel cookers - Solar Dryers - Solar Cooker Modeling - Hybrid Systems - solar thermal with conventional heat sources - Techno-Economic Analysis - Modeling and Simulation -Materials Research - AI-Powered Performance Prediction for Machine Vision.

UNIT- V: Solar Passive Architecture for Green H_2 Production:

Advanced Passive Solar Architecture - Green Hydrogen Production – electrolysis – photoelectrochemical water splitting and biological hydrogen production - Energy and Mass Transfer-Thermal Management of Electrolyzers - pre-heat water - passively cool Integration with Building Design - Natural Ventilation for Hydrogen Facilities - solar chimneys - Building Energy Simulation - techno-economic analysis - Computational Fluid Dynamics (CFD) - Life-Cycle Assessment (LCA) - Experimental Design on solar thermal applications.

Textbooks:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics the Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer "Hemisphere Publishing Corporation, New York, USA,1984
3. Subas, V.Patankar, "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Tapan K. Sengupta, "Fundamentals of Computational Fluid Dynamics" Universities Press, 2011.
5. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
6. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010.
7. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
8. Mills. A.F, Ganesan V.," Heat Transfer", 2nd ed., Pearson, 2009.
9. Minkowycz .W.J, Sparrow. E.M, Murthy J.Y, "Handbook of Numerical Heat Transfer", 2nd ed., Wiley,
2006.
10. Kreith .F, Bohn.M. S, "Principles of Heat Transfer", 6th ed., Thomson, 2001.
11. Venkateshan. S.P, "Heat Transfer", Ane Books Pvt Ltd , New Delhi. 2009.

REFERENCE BOOKS:

1. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, Taylor and Francis, 2000
2. Chetan Singh Solanki, Solar Photovoltatics – Fundamentals, Technologies and Applications, PHI Learning Private limited 2011
3. Sukhatme S P, J K Nayak, Solar Energy – Principle of Thermal Storage and collection, Tata McGraw Hill, 2008.
4. Solar Energy International, Photovoltaic – Design and Installation Manual – New Society Publishers, 2006
5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2010.
6. Das .S.K, "Fundamentals of Heat and Mass Transfer", Narosa, 2010.
7. Duffie .J.A, Beckman W. A. "Solar Engineering of Thermal Processes", 3rd ed., Wiley, 2006.
8. Sachdeva .R.C, "Fundamentals of Heat and Mass Transfer", 4th ed., New Age, 2010.
9. Ghoshdastidar .P.S, "Heat Transfer", Oxford University Press, 2004.2.

25PHY307 – Aeronomy

UNIT – I: Neutral Atmosphere

Structure and Composition Nomenclature-Thermal structure of the atmosphere. Hydrostatic equation of the atmospheric structure. Scale height and geopotential height. Exosphere. Atmospheric composition. Dissociation and diffusive separation and thermospheric composition. Heat balance and temperature profile of thermosphere, Influence of space weather events on the thermosphere.

UNIT – II: Chemical Concepts In Atmosphere

Thermodynamic considerations – Enthalpy. Elementary chemical kinetics- Reaction rate constants and chemical life time of species. Unimolecular, bimolecular and intermolecular reactions. Effect of dynamics on chemical species, Ion-neutral chemistry in the mesosphere and thermosphere.

UNIT – III: Ionized Atmosphere

Photochemical processes in the ionosphere Introduction to ionosphere – discovery. Continuity equation and photochemical equilibrium. Theory of photo-ionization and Chapman production function. Chemical recombination and electron density. Solar radiation and production of ionospheric layers, Data assimilation techniques using GNSS and satellite measurements.

UNIT – IV: Ionized Atmosphere

Loss reactions Different types of recombination processes. Chemistry of E and F1 regions. D region balance equations. D region chemistry – formation of water cluster ions. Electron attachment and negative ions. Positive and negative ion schemes of D region. Linear and square law loss formulae and splitting of F layer. Vertical transport, ambipolar diffusion and F2 peak. Diffusion between ionosphere and protonosphere. Airglow, AI-based prediction of ionospheric disturbances.

UNIT – V: Ionospheric Morphology & Disturbances

Geographical and temporal structure of the ionosphere – Diurnal, seasonal and solar cycle variations of D, E and F regions and F region anomalies. Solar flare effects Sudden Ionospheric Disturbances (SIDs), Ionospheric scintillation and its impact on communication/navigation systems, Space weather forecasting and ionospheric response, Role of geomagnetic storms and substorms in ionospheric morphology.

Textbooks

1. Schunk, R.W., and Nagy, A.F.Ionospheres: Physics, Plasma Physics, and Chemistry (2nd Edition). Cambridge University Press, 2009. ISBN: 978-0521877060.
2. Rishbeth, H., and Garriott, O.K. Introduction to Ionospheric Physics. Academic Press, 1969. ISBN: 978-0125884011.
3. Brasseur, G.P., and Solomon, S.Aeronomy of the Middle Atmosphere (3rd Edition). Springer, 2005. ISBN: 978-1402032824.

Reference Book

1. Schunk, R.W., and Sojka, J.J.Ionospheric Data Assimilation and Modeling. Springer, 2019. ISBN: 978-3319916328.

25PHY306 – Thin Film Technology and Applications

UNIT- I: Introduction of thin films Preparation of Thin films - Different synthesis methods of the thin films-films Kinetic aspects of Gases in a vacuum chamber - Classifications of vacuum ranges Production of vacuum - Pressure measurement in vacuum systems - Physical vapor deposition - Evaporation Techniques - Sputtering (RF & DC) - Pulsed Laser deposition Liquid Phase Epitaxy- Vapor Phase Epitaxy- Molecular Beam Epitaxy.

UNIT- II: Synthesis methods of thin films

Film growth and measurement of thickness - Film growth – five stages - Incorporation of defects and impurities in films - Deposition parameters and grain size - structure of thin films - quartz crystal monitor photometric - Ellipsometry and interferometers - Measurement of rate of deposition using rate meter - cleaning of substrate.

UNIT- III: Characterisations of thin films

Characterization, X-ray Diffraction (XRD) - SEM, Photoluminescence (PL) - Raman Spectroscopy, UV-Vis-IR Spectrophotometer – AFM - Hall effect – SIMS - X-ray Photoemission Spectroscopy (XPS) - Vibrational Sample Magnetometers, Rutherford Back Scattering (RBS). Differential scanning spectrometry (DSC), Fourier transform spectroscopy (FTIR), Conductivity testing, Discharge characterization, LSV, CVV.

UNIT- IV: Properties of the thin films

Properties of thin films Dielectric properties - Experimental techniques for dielectric film - annealing effect, effect of film thickness on dielectric properties – determination of optical constants – Experimental techniques for determination of optical parameters - Magnetic and mechanical properties - Hall effect compilations - Adhesion, stress, strength, Raleigh surface waves - Ferromagnetic properties of thin films.

UNIT- V: Applications of thin films

Applications, Micro and optoelectronic devices, quantum dots, Data storage, Polymer films, MEMS, optical applications - Applications in electronics – electric contacts, connections and resistors, capacitors and inductances - Applications of ferromagnetic and super conducting films - integrated circuits - thin films in optoelectronics and integrated optics

Textbooks:

1. K.L. Chopra, Thin film phenomena, McGraw- Hill book company New York, 1969
2. Ludminla Eckertova, 'Physics of thin films', Plenum press, New York1977.
3. A. Goswami, Thin Film Fundamentals, New Age international (P) Ltd. Publishers, New Delhi (1996).
4. K. L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969.

Reference Books:

1. Thin-Film Deposition: Principles and Practice, McGraw-Hill, 1995.
2. Materials Science of Thin Films, Academic Press, 2nd Ed., 2002.

25PHY207 - Particle Physics-I

Unit – I: Elementary particle physics

Elementary particles and their interactions, Quark and leptons. Discrete symmetries, C, P, T symmetries and CPT theorem (without proof) and its consequences. Parity of charged and neutral pions, photons, leptons and quark, C-parity of neutral pion and eta, Party violation in β-decay, Measurement of Helicity of Neutrino.

Unit - II: Hadron Spectroscopy and Quark Model

Nucleon as a composite particle. Nucleon resonances and baryon spectroscopy. Isospin: SU(2), SU(3) symmetry and classification of particles and resonances. Quark model of hadrons, Properties of quarks and their classification, Color degree of freedom, Gell-Mann – Okubo mass relation, Introduction to Standard Model, Fundamentals of Quantum Chromodynamics. Quark model of hadrons, Properties of quarks and their classification, Color degree of freedom, Gell-Mann – Okubo mass relation, Introduction to Standard Model, Fundamentals of Quantum Chromodynamics.

Unit – III: Relativistic Kinematics

Review of Lorentz transformations for energy and momentum, four-vectors and invariants, Laboratory and Centre-of-momentum systems, calculation of energy, momentum and angle of particles produced in nuclear reactions in Lab. and centre-of-momentum frames and their transformations and calculation of threshold energies for particle production. Mandelstam variables, Rapidity variable and invariance of rapidity distribution in lab and CM system, Maximum and minimum rapidities, Pseudorapidity distribution in projectile, target and central fragmentation regions.

Unit - IV: High Energy Hadron-Nucleon

Features of relativistic hadron-nucleon collisions upto very high energy, behaviour of elastic, inelastic and total cross-sections as a function of incident energy, multiplicity distribution, Negative Binomial Distribution, KNO scaling and Feynman scaling.

Unit – V: High Energy Hadron-Nucleus Interactions

Two-particle correlations, short- and long-range multiplicity correlations, particle correlation and clusterization, Multiplicity fluctuations, Entropy and its generalization, Shanon and Renyi entropies, Intermittency and beyond-, erraticity, Multifractality and multifractal specific heat.

Textbooks:

1. H. Pilkuhn, The Interactions of Hadrons (First Edition), North-Holland, 1967.
2. L. P. Martin, High Energy Hadron Physics (First Edition) ,John Wiley & Sons, 1974.
3. P. D. B. Collins & A. D. Martin, Hadron Interactions (First Edition), Adam Hilger Ltd., 1984.
4. R. Hagedorn, Relativistic Kinematics: A Guide to the Kinematic Problems of High-Energy Physics (Reprint Edition), W. A. Benjamin, 1973.

Reference Books

1. D. H. Perkins, Introduction to High Energy Physics (Fourth Edition), Addison Wesley, 2000.
2. F. Halzen and A. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics (Reprint Edition), John-Wiley, 2008.
3. C. Y. Wong, Introduction to High Energy Heavy Ion Collisions (First Edition), World Scientific, 1994.

25PHY309 - Particle Physics-II

Unit - I: Ultra-relativistic Nucleus-Nucleus Collisions

Glauber model of nucleus-nucleus collision, participant-spectator model, Bjorken estimate of the initial energy density, hadron structure and quark confinement, hydrodynamics of Quark-Gluon Plasma and phase diagram, deconfinement phase transition, Nuclear stopping power and nuclear transparency, Space-time picture of collisions, Time history of ultra-relativistic AA collisions, Geometry of heavy ion collisions.

Unit – II: Observables & QGP signatures

Signatures of Quark-Gluon Plasma formation, dilepon production, Drell-Yan Process in nucleus-nucleus collision, direct photon production, De-bye screening in the QGP, J/ψ suppression in the QGP, strangeness enhancement, correlation and event-by-event fluctuations, Handbury-Brown-Twiss effect, transverse mass, transverse energy, an isotropic flow and jet quenching.

Unit - III: Detectors in High Energy Physics Experiments

Review of Particle Accelerations and Detectors, Linacs, Synchrotrons and colliding-beam accelerators, principle of Cerenkov counters and calorimeters. Ionization, drift and diffusion of charges in gases, pulse formation and its shape in proportional counters, Multiwire proportional counter, drift chamber, Di-Muon Spectrometer of ALICE and MuCh of CBM, Idea of radiation length and critical energy, electromagnetic shower and hadronic shower detectors, Physics scenarios at RHIC and LHC energies.

Unit – IV: Introduction to data analysis

Luminosity, Event rate, hits, primary vertex, tracks, secondary vertex, trigger and pileup.Concept of detector and electronic noise, Detector calibration, Acceptance and Efficiency estimation, event and physics trigger selection, analysis for physics objectives. Particle identification in high energy experiments: dE/dx, Range, TOF technique, Transition radiation.

Unit - V: Monte-Carlo Simulation and Event Generator

Input from detectors for data analysis, Pattern recognition and track reconstruction, Event reconstruction, Event generators, Detector simulation.
Introduction to monte carlo (MC) event generators: HIJING, PYTHIA, UrQMD, AMPT.

Textbooks:

1. R. N. Cahn and G. Goldhaber, The Experimental Foundations of particle physics (Second Edition), Cambridge University Press, 2009.
2. W. R. Leo, Techniques For Nuclear and Particle Physics Experiments : How to approach (Second Edition), Springer-Verlag, 1994.
3. T. Ferbel, Experimental Techniques in High Energy Nuclear and Particle physics (Second Edition), World Scientific, 1991.
4. R. C. Fernow, Introduction to Experimental particle physics (Revised Edition), Cambridge University Press, 2023.

Reference Books

1. P. Bevington and D.K. Robinson, Data Reduction and Error analysis for the physical sciences (Third Edition), McGraw-Hill Education, 2002.
2. R. Frunwirth, M. Regler, R. K. Bock and H. Grote, Data analysis Techniques for High Energy physics (Second Edition), Cambridge University Press, 2000.
3. K. Kleinknecht. Detectors for Particle Radiation (Second Edition), Cambridge University Press, 1998.
4. T. Ferbel, Experimental Techniques in High Energy Physics (First Edition), Addison-Wesley, 1987.

25PHY208 - Phosphors for Lighting Applications

UNIT-I: Fundamentals of phosphors

Fundamentals of luminescence: Absorption and emission of light, electronic states and optical transition of solid crystals, Luminescence of a localized center, Impurities and luminescence in semiconductors, Transient characteristics of luminescence, Excitation energy transfer and cooperative optical phenomena, Excitation mechanism of luminescence by cathode-ray and ionizing radiation, Inorganic electroluminescence, Lanthanide level locations and its impact on phosphor performance.

UNIT-II: Properties of phosphors

Principal phosphor materials and their optical properties: Luminescence centers of ns^2-type ions, Luminescence centers of transition metal ions, Luminescence centers of rare-earth ions, Luminescence centers of complex ions, Ia-VIIb compounds, IIa-VIb compounds, IIb-VIb compounds, ZnSe and related luminescent materials, IIIb-Vb compounds, (Al,Ga,In)(P,As) alloys emitting visible luminescence, (Al,Ga,In)(P,As) alloys emitting infrared luminescence, GaN and related luminescence materials, Silicon carbide (SiC) as a luminescence material, Oxynitride phosphors.

UNIT-III: Methods of phosphor synthesis and related technology:

General technology of synthesis, Inorganic nanoparticles and nanostructures for phosphor applications, Preparation of phosphors by the sol–gel technology, Surface treatment, Coating methods, fluorescent lamps, Mercury lamps, Intensifying screens (Doctor Blade Method), Dispersive properties and adhesion strength.

UNIT-IV: Types of phosphor

Phosphors for lamps: Construction and energy conversion principle of various lamps, Classification of fluorescent lamps by chromaticity and color rendering properties, High-pressure mercury lamps, Characteristics required for lamp phosphors, Practical lamp phosphors, Phosphors for high-pressure mercury lamps, Phosphors for white light-emitting diodes.

Electroluminescence materials: Inorganic electroluminescence materials, Inorganic electroluminescence, Organic electroluminescence

Phosphors for plasma display: Plasma display panels, Discharge gases, Vacuum-ultraviolet phosphors and their characteristics, Characteristics of full-color plasma displays, Plasma displays and phosphors.

UNIT-V: Measurements of phosphor properties

Measurements of luminescence properties of phosphors: Luminescence and excitation spectra, Reflection and absorption spectra, Transient characteristics of luminescence, Luminescence efficiency, Data processing, Measurements in the vacuum-ultraviolet region.

Measurements of powder characteristics: Particle size and its measurements, Methods for measuring particle size, Measurements of packing and flow.

Textbooks

1. Phosphors Handbook, Second Edition, William M. Yen, Shigeo Shionoya, Hajime Yamamoto, CRC Press.
2. Rare Earth Activated Phosphors, Vikas Dubey, Neha Dubey, Marta Michalska Domanska, M Jayasimhadri, Sanjay J. Dhoble, Elsevier.

Reference Book

1. Phosphors Handbook: Process, Properties and Applications, Vijay B. Pawade, Ritesh L. Kohale, Sanjay J. Dhoble, Hendrik C. Swart, Woodhead Publishing Series in Electronic and Optical Materials, Elsevier.

25PHY209 – Synthesis and Characterization of Materials

UNIT-I: Physical and Chemical routes for synthesis of Materials

Introduction to Synthesis methods and types, Melt Quenching Method, High Energy Ball Milling, Solid State Reaction method, Inert gas condensation, Role of inert gases- Post oxidation process; Chemical Precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, Solvo-thermal synthesis. Different types of Sputtering processes – Pulsed laser deposition – Rapid solidification – Arc discharge method- Fabrication of Nanostructures Microfabrication using Etching-Lithography; Thermolysis routes, Microwave heating synthesis; Sono-chemical synthesis.

UNIT-II: Structural Characterization methods

Introduction to different characterization techniques, X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and EDAX analysis, Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM). Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy AFM)-Non-contact, contact- Tapping- conducting mode, Near Field Scanning Optical Microscopy; Scanning Capacitance Microscopy- Magnetic Force Microscopes (MFM), Chemical Force Microscope (CFM).

UNIT-III: Spectroscopic and Magnetic Characterization methods

Basic concepts of spectroscopy, Raman spectroscopy-operational principle and application for analysis of materials, Fourier Transform Infrared Spectroscopy (FTIR), UV-VIS-IR Spectroscopy, Photoluminescence (PL), Principle of operation and application for band gap measurement. Vibrational Sample Magnetometer (VSM).

UNIT-IV: Surface and Thermal characterization methods

X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy, BET Analysis, Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy, Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).

UNIT-V: Electrical and Electrochemical and Biomaterials Characterisation Methods

Cyclic Voltammetry (CV), Charge-discharge studies (C-D), Semiconducting Quantum Interference Device (SQUID), Electrochemical Impedance Spectroscopy (EIS), Four probe method. New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes- Confocal Raman – Application in Nano-biotechnology. Fluorescence Microscope.

Textbooks

1. G. Cao, “Nanostructures & Nanomaterials: Synthesis, Properties & Applications”, Imperial College Press, 2004.
2. Elton N. Kaufmann, characterization of materials, Wiley Interscience, 2003
3. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.

Reference Books:

1. Chemistry of Nanomaterials: Synthesis, Properties and Applications - CNR Rao, H.C. mult.Achim Müller, A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 9783527306862, 9783527602476, 2004.
2. Carl. C Koch, "Nanostructured Materials: Processing, Properties and Potential Applications", William Andrew Publishing Norwich, 2006.
3. Dieter Vollath, Nanoparticles – Nanocomposites – Nanomaterials An Introduction for beginners, Wiley 2013
4. R.W. Cahn, E.M. Lifshitz, Concise Encyclopedia of Materials Characterization: Advances in Materials Sciences and Engineering, Elsevier, 2016.
5. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons, 2013.
6. Tseung-Yuen Tseng and Hari Singh Nalwa, Handbook of Nanoceramics and their Based Nanodevices (Vol. 2), American Scientific Publishers, 2005.