Qn. M. 1.2.1(3)

PHYSICS New courses introduced (3)

Final

PST-1.5 (a): Instrumentation

Unit – I: Generalized Characteristics of Instruments

13 Hours

Static characteristics: accuracy, precision, repeatability, reproducibility, resolution, sensitivity, linearity, drift, span, range.

Dynamic characteristics: transfer function , zero order instruments, first order instruments – step, ramp, frequency responses – second order instruments – step-ramp response – dead time elements.

Types of Errors: gross, systematic, random, linear and nonlinear curve fitting, chi-square test

Unit – II: Vacuum Systems

13 Hours

Principle and operation of various pumps: rotary, diffiusion, sorption, turbomolecular, ionisation and cryopumping.

Gauges: McLeod, diaphragm, thermocouple, pirani, penning, ionisation and hot and cold cathodes – design of high vacuum systems – high pressure cells – measurements at high pressures.

Unit – III: Thermal Systems

13 Hours

Temperature scales – liquefaction of gases, achieving low temperature – design of cryostats. High temperature furnaces: resistance, induction and arc furnaces – high temperature measurements – pyrometers – total and selective radiation pyrometers – optical pyrometer.

Unit – IV: Detectors and Spectroscopy

13 Hours

Detectors: pyroelectric, thermoelectric, photoconducting, photoelectric, photomultiplier, scintillation types of detectors, photon counters.

Spectroscopy: principles of atomic absorption spectroscopy – instrumentation – single and double beam spectrometers –theory and components of nuclear quadrupole resonance technique – applications.

References:

1) A.K. Sawhney and Puneet Sawhney, A Course in Mechanical Measurement and Instrumentation, DhanpatRai&Sons, New Delhi 2000.
2) Dennis Roddy and John Coolen, Electonic communication, 4th edition, PHI private Ltd., (1999). (Unit – II)
3) C.S. Rangan, G.R. Sharma and V.S.V. Mani, Instrumentation Devices and Systems, Tata McGraw-Hill (1983).
4) H.H. Willard, L.L. Merrit and John A. Dean, Instrumental Methods of Analysis, 6th edition, CBS Publishers & Distributors (1986).
5) D.V.S. Murty, Transducers and Instrumentation, Prentice – Hall of India (P) Ltd., New Delhi (1995).
6) Ernest O. Doebelin, Measurement System Applications and Design, McGraw Hill International Book Company, Singapore (1983)

PST-4.3(b): Advanced Statistical Mechanics and Phase Transition

Unit – I: **13 Hours**

Probability and Random Process: Fluctuations and random processes – Brownian motion – diffusion – random walks – Langevin equation – fluctuation-dissipation theorem – irreversibility – Markov processes – master equation – Fokker -Planck equation.

Unit – II: **13 Hours**

Phase Transition Theories: Examples of first order and continuous phase transitions – mean field (van der Waals and Weiss molecular field) theories – fluid-magnet analogy – correlations – classical (Ornstein -Zernicke) theory.

Statistical Mechanical Models: Ising, lattice gas, Heisenberg, XV and Potts models – transfer matrix method –illustration using one-dimensionallising model – duality in the two-dimensionallsing model – high and low temperature series expansions.

Unit – III: **13 Hours**

Critical Phenomena: Long-range order, order parameter, scaling, universality, critical exponents – Peierls argument for phase transitions – spontaneous breakdown of symmetry – Landau theory of phase transitions – role of fluctuations, lower and upper critical dimensions – GinzburgLandau model – Higgs mechanism – examples – Mermin-wagner theorem – topological (Berezinski-Kosterlitz-Thouless) phase transition.

Unit –IV: **13 Hours**

Renormalization Group Theory: Elements of re-normalization group approach to continuous phase transitions –flows in parameter space, fixed points, epsilon expansion, real-space re-normalization – connection with Euclidean field theories – elementary ideas on percolation.

References:

1) N.G. Van Kampen, Stochastic Processes in Physics and Chemistry, North-Holland (1985).
2) H.E. Stanley, Introduction to Phase Transitions and Critical Phenomena, Clarendon Press, Oxford (1971).
3) J.M. Yeoman, Statistical Mechanics of Phase Transitions, Clarendon Press, Oxford (1992).
4) C.W. Gardiner, Handbook of Stochastic Methods, Springer-Verlag (1983).
5) C.J. Thompson, Classical Equilibrium Statistical Methods Springer-Verlag (1988).
6) D. Stauffer, Introduction to Percolation Theory, Taylor and Francis (1985).

PHDPH1: Research Methodology

UNIT I:Research Methodology: (14hrs)

Introduction, Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers. Defining the Research Problem: identifying research area and topic, current national and international status of topic, developing a research plan.

UNIT II: Literature Survey and Research Design (14hrs)

Review of Literature: literature review in research, Bringing clarity and focus to research problem, Improving research methodology, Broadening knowledge base in research area, Literature survey – Scientific Journals (full length papers and review articles), magazines, thesis, dissertation, monographs, internet browsing (through search engines), Enabling contextual findings, Review of the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, need for Research Design, features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

UNIT III: Funding Agencies and IPR (14hrs)

Idea about the funding agencies - DST, UGC, CSIR, DAE-BRNS, ISRO and student funding. Intellectual Property Rights (IPR) –importance of intellectual property and its protection, the role of IPR in research and development, IPs of relevance to physics and few case studies Patents: Definition, filing procedure, licensing, Copyright and related rights, research ethics, plagiarism, types of plagiarism.

UNIT IV: Interpretation, Report writing and Computer programming (14hrs)

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Computer Programming – Basic components of MS Word, Origin Graphics, linear and curve fitting in origin graphics, programming in C++ (some examples), basics of MATHEMATICA and MATLAB

Reference Books:

1. C. R. Kothari, A Research Methodology, Methods and Techniques, New Age International Publisher, 2004.
2. Won Y., Yang, W. Cao, Tae-Sang Chung and John Morris, Applied Numerical Methods using MATLAB, Wiley Student Edition, 2005.
3. M. K. Jain, S. R. K., Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Ltd.
4. Philip R. Bevington and D. Keith, Robinson, Data Reduction and Error Analysis for the Physical Science (3rd Ed.), McGraw-Hill, 2003.
5. Paul G., Chapin, Research Projects and Research Proposal – A Guide for Scientists seeking funding, Cambridge University Press.

6. Bhate and Pongashe, Management of Intellectual Property, Prakashan, Pune, 1988.

7. E. Bright Wilson, An Introduction to Scientific Research.

PHDPH2.1: Fluorescence Spectroscopy

UNIT I: Introduction to Fluorescence: (14 hours)

Phenomena of fluorescence, Jablonski diagram, characteristics of fluorescence emission, fluorescence lifetime and quantum yields, fluorescence anisotropy, Resonance energy transfer, steady-state and time-resolved fluorescence, Biochemical fluorophores, Molecular information from fluorescence: Emission Spectra and the Stokes Shift, Intrinsic or Natural Fluorophores Extrinsic Fluorophores, DNA Probes, Chemical Sensing Probes and Special Probes, other Fluorescent Proteins, Long-Lifetime Probes: Lanthanides, Transition Metal–Ligand Complexes, Proteins as Sensors. New fluorescence technologies, overview of fluorescence spectroscopy.

UNIT II: Instrumentation for Fluorescence Spectroscopy: (14 hours)

Spectrofluorometers for Spectroscopy Research, Spectrofluorometers for High Throughput, An Ideal Spectrofluorometer, Distortions in Excitation and Emission Spectra, Different Light Sources used in Spectrofluorometers, Monochromators- Wavelength Resolution and Emission Spectra, Polarization Characteristics of Monochromators, Stray Light in Monochromators, Second-Order Transmission in Monochromators, Calibration of Monochromators, Optical Filters - Colored Filters, Thin-Film Filters, Filter Combinations , Neutral-Density Filters, Photomultiplier Tubes - Spectral Response, Design and Dynode Chains, Time Response of PMTs, Photon Counting versus Analog Detection of Fluorescence, Symptoms of PMT Failure, CCD Detectors, Corrected Excitation Spectra Using a Quantum Counter, Corrected Emission Spectra - Comparison with Known Emission Spectra, Corrections Using a Standard Lamp, Correction Factors Using a Quantum Counter and Scatterer, Conversion between Wavelength and Wavenumber, Quantum Yield Standards. Overview of Time-Domain and Frequency- Domain Measurements: Meaning of the Lifetime or Decay Time, Phase and Modulation Lifetimes, Examples of Time-Domain and Frequency-Domain Lifetimes, Time-Correlated Single-Photon Counting - Principles of TCSPC, Example of TCSPC Data, Convolution Integral, Light Sources for TCSPC.

UNIT III: Solvent and Environmental Effects: (14 hours)

Overview of solvent polarity effects, general solvent effects: The Lippert-Matega equation, specific solvent effects, temperature effects, phase transitions in membranes, additional factors that affect emission spectra, effects of viscosity, Probe-Probe interactions, Biochemical applications of environment-sensitive fluorophores, advanced Solvent -Sensitive Probes, effects of solvent mixtures, summary of solvent effects.

UNIT IV: Quenching of Fluorescence: (14 hours)

Quenchers of fluorescence, Theory of collisional quenching, Theory of static quenching, combined dynamic and static quenching, examples of static and dynamic quenching, deviations from the Stern-Volmer equation: quenching sphere of action, effects of steric shielding and charge on quenching, fractional accessibility to quenchers, application of quenching to Proteins, application of quenching to membranes, lateral diffusion in membranes, quenching –resolved emission spectra, quenching and association reactions, sensing applications of quenching, sensing applications of quenching to Molecular Biology,

quenching on Gold surfaces, intermolecular quenching, quenching of phosphorescence.

Reference Books:

1. K. K. Rohatagi and Mukharjee, Fundamentals of Photochemistry.
2. J R Lakowicz, Principles of Fluorescence Spectroscopy.
3. Michael D. Limb, Luminescence Spectroscopy
4. Douglas A. Skoog, F. James Holler & Timothy A : Principles of Instrumental Analysis
5. Skoog, Moller and Nieman, Principles of Instrumental Analysis.

PHDPH2.1: Materials Science

Unit 1: Introduction to Materials (14 Hours)

Classification and properties of materials, Significance of structure property relationship, Bonding and crystal Structure of solids materials, Imperfections in solids, Diffusion phenomenon, Principles of solidification, Nucleation and Growth process, Phase diagrams and phase transformations, various strengthening mechanism, cold working, Recovery, Recrystalization, Grain growth; Introduction to metallic, semiconductor, ceramic, superconductor, composite materials, Various Properties of materials: Electrical, Optical, Mechanical and Magnetic properties.

Unit 2: Ferroelectrics, Ferrites and Composite Materials (14 Hours)

Ferroelectrics: Properties of ferroelectrics, classification and properties ofrepresentative ferroelectric crystals, theory of ferroelectricity, piezo and pyro electric properties, dielectric constant with temperature and frequency, hysteresis loop.

Ferrites: definitions and types of ferrites with examples, structure of cubic ferrite, saturationmagnetization, molecular field theory, hexagonal ferrite, influence of temperature and field on magnetic behavior, domains, hysteresis, applications of ferrites.

Composite Materials: Introduction to composites, types of composites, single phase MEmaterials, composite ME materials, ME effect, properties of ME composites; sum properties, product properties, combination property, conditions for getting good ME output in composites, application of ME composites in different fields.

Unit 3: Polymer Material Science (14 Hours)

History and basic nature of polymers, Classification ofPolymers and processing techniques, the structure, and physical properties of plastics, thermoplastics and thermosets, processing techniques of polymers: Extrusion, Injection molding, Thermoforming, Compression molding and Transfer molding. Glass Transition temperature ofpolymers. Thermodynamics of polymerization. Polymer surfactant interactions.

Unit 4: Nanomaterials (14 Hours)

Introduction to nanomaterials: methods based on evaporation, sputter deposition, chemical vapor deposition, electric arcdeposition etc. Chemical methods of synthesis, colloidal route: metal and semiconductornano particle synthesis, microemulsion, organic capping of nano materials. Properties of nanomaterials: mechanical, structural, melting point depression, electrical conductivity and opticalproperties.

Reference Books:

1. Introduction to Magnetic Materials, B. D. Cullity, C. D. Graham, (Wiley) 2nd ed.
2. Composite Materials Science and Applications, Deborah. D. L. Chung, (Springer).
3. Elementary Solid State Physics. M. Ali Omar, Pearson Edu. Inc, 2016
4. The Physical Principles of Magnetism, Allan. H. Morrish, (IEEE Press)
5. Polymer Science & Technology of Plastics & Rubber, P. Ghosh, Tata McGraw Hill, 2000.
6. Polymer Science V R Gowrikar et.al. New Age International Pvt. Ltd. 2005
7. Nanotechnology: Importance and applications by M H Fulekar IK Int. pvt. Ltd 2010

PHDEL3: Literature Review

Review Writing & Seminar on the Published Research Work in the Relevant Field of study:

A minimum of 30 Articles shall be reviewed by the M.Phil./Ph.D. candidate and submit a review report, in two copies, on topic of subject or area of interest in subject, under the supervision of the research guide, and will also give a presentation/seminar of the same during term end Viva-Voce examination before the Doctoral Committee.

PHDPH4: Research and Publication Ethics (RPE)

Unit 1: Philosophy and Ethics (Theory) (03 hours)

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit 2: Scientific Conduct (Theory) (05 hours)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

Unit 3: Publication Ethics (Theory) (07 hours)

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals.

Unit 4: Open Access Publishing (Practice) (04 hours)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archivingpolicies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/Journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester etc.

Unit 5: Publication Misconduct (Practice) (04 hours)

A. Group Discussions (2 hours)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hours)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit 6: Databases and Research Metrics (Practice) (07 hours)

A. Databases (4 hours)

1. Indexing databases
2. Citation databases: Web of Science, Scopus etc.

B. Research Metrics (3 hours)

1. Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics.