Course No. PHDPHY01
Research Methodology and Research Techniques in Physics

Unit-1

Research methodology and research methods, methodology–selecting a topic, hypothesis, experiment, analysis and results; non-experimental or theoretical research, critical thinking, investigation, survey, a*b initio,* semi-empirical, empirical search; Inquiry, Quest, Exploration, innovation (innovative ideas), Discovery and Invention in science; knowledge and creativity

A flow-chart of research leading to degree, Literature survey through web and other related resources, scientific report/paper writing, documentation in Latex,

Quality of research, quantitative measurement by Impact factor, h-index, Scientometry, etc.

Unit-2

Uncertainties in Measurements: Measuring Errors, Uncertainties, Parent and Sample Distributions, Mean and Standard Deviation of Distributions, Binomial Distributions, Poisson Distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution; Approximation and Errors in Computing: Significant Digits, Numerical Errors, Modelling errors, Conditioning and Stability, Convergence of Iterative Processes.

Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Application of Error Equations, method of Least squares, Statistical Fluctuations, Probability Tests, χ^2 Test of a distribution.

Unit-3

Curve fitting (Regression Analysis); Least square Fit to a Straight line, error estimation of the fitted parameters, limitations of the least square method, Least squares fit to a polynomial, matrix solution, Goodness of a fit, Linear Correlation Coefficient, Multivariable Correlations.

Monte Carlo techniques: Random numbers, Random numbers from Probability Distributions, Specific Distributions, Efficient Monte Carlo generation, Confidence Intervals, Monte Carlo Tests for the Fit – Applications.

Numerical solutions of Transcendental Equations and Ordinary Differential Equations, Runge-Kutta Methods

Unit -4

Basics of computer languages, Basics of C-language, Programming in C, Arrays, functions, conditional statements, Applications, Introduction to Mathematica, numerical calculations and Built-in functions, Basic algebraic operations on Expressions, Defining and evaluating Functions, Graphs of two dimension and Three dimension, Exact and approximate Solutions of Equations, Computing derivatives of explicit and implicit functions, Computing definite and indefinite Integrals, Applications related to ordinary and partial differential equations

Books:

1. The Scientific Endeavor-Methodology and Perspectives Of Sciences by Jeffrey A Lee; Publisher: Pearson Education India
2. Research Methods for Science, M. P. Marder, Cambridge University Press, 2011.

3. Research Methodology Techniques and Trends, Y. K. Singh and R. B. Bajpai, APH Publishing Corporation House, 2008.
4. Data Reduction and Error Analysis for the Physical Sciences 3rd Ed. by Philip R Bevington& D Keith Robinson, McGraw – Hill (2003)
5. Numerical Methods by Balagurusamy, Tata McGraw – Hill (2000)
6. Numerical Analysis, 2nd Ed. by Francis Scheid, McGraw-Hill (2009)
7. Numerical mathematical Analysis, James B Scarboroughs
8. Numerical Methods for Scientists and Engineers, K Sankara Rao, 3rd Ed. PHI
9. Computer Programming in Fortran90 and 95 by V Rajaraman, Prentice Hall of India 2001
10. Computer Programming in C by V Rajaraman, Prentice Hall of India
11. Mathematica by Examples, revised edition, Martha L Abell and James P Braselton, AP Professional, Boston, 1994.
12. Mathematica for the sciences by Richard E Crandall, Addison-Wesley Pub. Co. Inc. 1991
13. LATEX for Engineers and Scientists by David J Buerger, McGraw Hill Pub. Co., NY, 1990.

Course No. PHDPHY02
Experimental Physics – I

Unit-1

Methods of Synthesis of Nanomaterials: Grinding, Gas condensation, Laser ablation, RF Plasma, Chemical method, Thermolysis, Sol-Gel, Pulsed Laser method.

Characterization techniques: Infrared and Raman spectroscopy, Photoluminescence and X-ray spectroscopy, Magnetic Resonance.

Applications: MEMS, NEMS, Nanodevices and Nanomachines.

Unit-II

Defect in crystals: Point, line, surface and volume defects.

Movement of dislocations: velocity of dislocations, cross-slip and climb.

Thomsons tetrahedron, Sessile dislocation, Lomer-cottrell sessile dislocation, Tetrahedral defects.

Unit-III

Nucleation, homogeneous and heterogeneous nucleation, Bridgman and related methods-basic processes, Czochralski and related methods: Kyropoulos growth, Dendrite method, Stepanov method, edge define film fed growth, Verneuil process, floating zone process, solution growth, gel growth, vapour transport technique.

Unit-IV

Production, Properties and Applications of X rays, Geometry of crystals, Diffraction from Crystals, Diffractometer measurements for polycrystalline materials and determination of crystal structure. Single crystal diffractometer and the uses. Macromolecule-protein and different crystallization techniques.

Books:

1. Introduction to Nanotechnology By Charles. P. Poole Jr. Frank J. Owens (Wiley Edition).
2. Nanotechnology and Nanoelectronics by W. R. Fahrnar (Ed.) (Springer).
3. Introduction to dislocation by D. Hull.
4. Crystal growth processes by J.C.Brice.
5. Crystal growth processes and methods by P. Santhana and P. Ramasamy.
6. Elements of X ray Diffraction – B.D.Cullity.
7. Crystal Structure analysis - M.J. Burgers.

Course No. PHDPHY03
Experimental Physics – II

Unit-1

Why UHV?, Vacuum concepts, UHV Materials, UHV pumping system: Pumps, Gauges, Valves, typical UHV pumping system, UHV Hardware, Preperation of atomically clean surfaces, UHV Deposition concepts, Thermal evaporation, Sputtering and Electron beam evaporation.

Commercially important other deposition techniques: Chemical Bath Deposition, Electro-deposition and Spin-coating, coating using ink-jet.

Unit-2

Production and measurement of high pressure: Introduction, properties of materials for high pressure systems, The transmission of pressure, basic considerations in pressure measurement, Practical methods of pressure generation: Gravitational methods, Thermodynamic methods, shock – wave methods, Piston methods- Single and multi stage, Pressure measurements and pressure scale: Primary pressure measurement, secondary measuring instruments-Phase change methods, Bourdon gauges, resistance gauges, pressure calibration points. Bridgman Anvil Cell and Diamond Anvil Cell

Unit-3

Hall Effect–Principle, theory, parameters; Resistivity– two & four probe methods; Seebeck coefficient, UV-Vis-NIR spectroscopy; Scanning Electron Microscopy–principle, secondary electrons, backscattered electrons; transmission electron microscopy–principle; X-ray energy dispersive analysis (EDX); X-ray photoelectron spectroscopy (XPS).

Unit -4

Principle of solar cells, Classification of Solar Cells, p-n junction solar cells, Dark and Illuminated characteristics, solar cell output parameters- efficiency, fill factor, series resistance, shunt resistance, Photovoltaic Devices II; Hetero-junction solar cells, MIS solar cells, Metal-semiconductor heterojunction- Schottky Junction Solar Cells, Liquid junction solar cells(PEC), Comparison of p-n junction and PEC solar cells, Dye Sensitized Solar Cells(DSSC) - Principle of operation, Materiales for DSSC, Advantages and limitations of DSSC.

Books:

1. Surface Science: an introduction by K. Oura (Springer)
2. Handbook of thin film technology by L.I. Maissel and R. Glang (McGraw-Hill).
3. Thin film Phenomena by K. L. Chopra (McGraw-Hill).
4. High pressure Physics and Chemistry Volume-1
   Editor: R.S.Bradley, Academic Press- London and New York-1963
5. Introduction to Solid State Physics – C. Kittel
6. Optical processes in semiconductor – J. I. Pankove
7. Solid State Physics – S. O. Pillai
8. The Materials Science of Thin Films – Milton Ohring
9. Solar cells- By Chenming Hu and Richard M. White, MGH Company.
10. Photoelectrochemical solar cells-Suresh Chandra, Gerdon and Breach Publications, NY.