DEPARTMENT OF PHYSICS

M.Phil. Restructured syllabus

(Effective from 2018-2019)

Semester	Nature	Code	Course title	Credits
I	MC	PH 1118	Techniques & Tools for Physicists	6
	MC	PH1157	Advanced Physics	6
	ES	PH1256	Crystal Growth	6
	ES	PH1157	Advances in Material Science	6
II	MC	PH 1217	Dissertation & Viva Voce	18
Total				36

PH 1118 - TECHNIQUES AND TOOLS FOR PHYSICISTS

Paper -I

Semester: I **Credits: 6**

Course: Major Core (MC) **Hours/week: 6**

1. Mathematical Methods of Physics

Vector algebra and vector calculus - Linear algebra, matrices, Cayley-Hamilton Theorem - Eigenvalues and eigenvectors. Linear ordinary differential equations of first and second order - Special functions (Hermite, Bessel, Laguerre and Legendre functions) - Fourier series, Fourier and Laplace transforms - Elements of complex analysis, analytic functions.

2. Numerical Methods

System of linear equations – Gauss-Jordan elimination method – iterative method – Newton – Raphson method – Numerical integration – Simpson's 1/3 rule – Simpson's 1/8 rule – Gauss – Legendre quadrature – Solution of differential equations – Runge- Kutta Methods. Interpolation – significance of interpolation – methods of interpolation – Binomial method – Newton's method – Newton's forward form – Newton's backward form –Finite differences – Lagrange's method

3. **Programming in C ++ and introduction to Matlab**

Introduction – constants, variables and data types – operations and expressions –arrays – one dimensional and two dimensional arrays – declaring and initializing string variables – user defined functions – pointers – file handling – defining and opening a file – closing a file – input/output operations in files – error handling – random access – command line – the processor – macro substitution – file inclusion – compiler control directive – Sample programs. **Matlab :** Problem Solving Using The Techniques Developed by learning C++

4. Method of Research

Objectives and motivation in research – types of research – research and scientific method – research problem – selecting the problem – techniques involved in defining the problem – research design – literature survey – data collection – the use of computers in research – access using internet web tools – e-mails – e-journals – uses of research engines – impact and usefulness of the research problem.

5. Experimental Techniques and data analysis

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors),

measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

REFERENCES

Unit 1

1. Advanced Engineering Mathematics by Erwin Kreyszig, 10th Edition, John Wiley & Sons (2011)
2. Special functions for scientists and engineers by W. W. Bell, Reprint, Courier Dover Publications (2004)
3. Schaum's Outline Series Theory And Problems Of Vector Analysis And An Introduction To Tensors Analysis by Murray R. Speigel, Tata Mcgraw Hill,(2004)
4. Laplace And Fourier Transforms –Goyal Gupta, Pragati Prakasan Edition 23,(2009)
5. Selected Topics in Mathematical Physics by Prof. V. Balakrishnan,Department of Physics,IIT Madras. NPTEL

Unit 2:

1. Numerical Methods by S.Balachandra Rao And C.K Shantha, Universities Press.,(2004)
2. Introductory methods of Numerical Analysis by S.S. Sastry, 5th edition, PHI Ltd., (2012)
3. Numerical Methods In Science And Engineering-M.K.Venketaraman, National Publishing Co, 1989.
4. Lecture series on Numerical Methods and Computation by Prof.S.R.K.Iyengar, Department of Mathematics, IIT Delhi - NPTEL

Unit 3:

1. Teach Yourself C++ by Herbert Schildt,Tata Mcgrew Hill., 3rd Edition .,(2002)
2. Object Oriented Programming with C++ Book by E. Balagurusamy Edition: 7, 2017

3. Technical Reference Manual of Mat lab

Unit 4:

1. Thesis and Assignment Writing by V.Anderson, B.H.Durston and M.Poole, Brisbane : John Wiley & Sons, (1994)
2. Hand Book of Methodology of Research by Rajammal Devadas, RMM Vidyalaya Press 1982.
3. Research Methodology: Methods and Techniques by C.R.Kothari, New Age International, (2018)
4. Research Methodology: A Step-by-Step Guide for Beginners Book by Ranjit Kumar Edition: 2nd Edition, 2005

Unit 5

1. Instrumental Methods of Analysis by H.H. Willard, L.L.Merrit J.A.Dean, F.A.Settle, CBS Publication and Distributers, New Delhi, (2004)
2. Instrumentation Measurement Analysis by BC Nakra, KK Chaudhry, Tata McGraw Hill (2004)/2e
3. Industrial Electronics and Control by SK Bhattacharya, S., Chatterjee, Tata McGraw Hill, New Delhi, (1995)

PH 1157 - ADVANCED PHYSICS

Paper - II

Semester: I **Credits: 6**

Course: Major Core (MC) **Hours/week: 6**

1. Classical Mechanics

Newton's laws, Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics moment of inertia tensor. Non-inertial frames and pseudo forces. Variational principle - Generalized coordinates - Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations,

normal modes. Special theory of relativityLorentz transformations, relativistic kinematics and mass–energy equivalence.

2. Electromagnetic Theory

Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

3. Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momentaVariational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection.

4. Electronics

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters.

5. Thermodynamics and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law.

REFERENCES

UNIT I

1. Classical Mechanics, by H.Goldstein, Charles Poole and John Sabko, 3rd edition, Pearson Education India, (2002)

2. Lagrangian and Hamiltonian mechanics, by M.G.Calkin, 1st Indian Reprint, Allied Publishers (2000)
3. Classical Mechanics By P.V.Panat, Narosa Publishers (2005)
4. Classical Mechanics By K.N.Srinivasa Rao, Universities Press (India) Pvt. Ltd, (2003)
5. Problems And Solutions On Mechanics,Ed. By Yung-Kuo Lim, Sarat Book House, (2001)
6. Lecture Series on Classical Physics by Prof.V.Balakrishnan, Department of Physics, IIT Madras - NPTEL

UNIT II

1. Introduction to electrodynamics by David Jeffery Griffiths, 4th edition, pearson (2013)
2. Classical electrodynamics by John David Jackson, 3rd edition, Wiley Eastern Ltd. (1999)
3. John David Jackson, Classical Electrodynamics, Second Edition-(1975), Wiley Eastern Ltd
4. Gupta, Kumar And Singh, Electrodynamcs, Second Edition (2001), Pragati Prakashan
5. A.Z. Capri And P.V Panat, Introduction To Electrodynamics, 2002, Narosa Publishing House
6. David J. Griffiths | Lectures | Techfest 2012, IIT Bombay - Youtube

UNIT III

1. Quantum Mechanics by G Aruldhas, Prentice Hall India Learning Pvt. Ltd., 2009
2. Quantum Mechanics by B. K. Agarwal, Hari Prakash, Prentice Hall India Learning Pvt. Ltd., 2009
3. A text book of Quantum Mechanics by K. Venkatesan and P. M. Mcgraw Higher Ed., 2010
4. Lecture Series on Quantum Physics by Prof.V.Balakrishnan, Department of Physics, IIT Madras – NPTEL

UNIT IV

1. Integrated Electronics, Analog & Digital Circuits and systems by Millman J. and Halkias C.C., McGraw–Hill 2nd edition, (2009)
2. Electronics Fundamental and applications by Chattopadhay D. and Rakshit, 13th Edition., New age publishers, 2016
3. John D. Ryder, Electronic Fundamentals and Applications Edition: 5thEdition, 2009
4. Malvino and Leach,Digital Principles and Applications Edition: 6thEdition, 2006
5. Electronics by Prof. D.C. Dube, Department of Physics, IIT Delhi -NPTEL

UNIT V

1. Thermodynamics and Statistical Mechanics by Walter Greiner – Springer – 3rd edition., (2001)
2. Thermodynamics, kinetic theory and statistical thermodynamics by Sears Salinger, 3 rd Edition., Narosa Publishing House.
3. Introduction to statistical mechanics by Kerson Huang, 2nd edition., CRC press (2008).
4. STATISTICAL MECHANICS by Donald A. McQuarrie, Viva Books Private limited,(2003).
5. STATISTICAL MECHANICS by Agarwal.B.K. and Melvin Eisner, New Age International Limited,(2003) 2nd Edition
6. STATISTICAL MECHANICS by Bhattacharjee, Allied Publishers limited,(1996).

PH 1256 – CRYSTAL GROWTH

Paper - III

Semester: I **Credits: 6**

Course: Elective Subject (ES) **Hours/week: 6**

1. NUCLEATION :

Different kinds of nucleation – equilibrium stability and metastable state – classical theory of nucleation – effect of soluble impurities on nucleation – determination of solubility – methods of induction period measurements – desupersaturation – steady state nucleation rate – nucleation parameters.

2. LOW TEMPERATURE GROWTH TECHNIQUES:

Low temperature solution growth - slow cooling and slow evaporation methods - temperature gradient method - criteria for optimizing solution growth parameters - basic apparatus for solution growth. Gel growth - structure of silica gel and gelling mechanism - nucleation control - merits of gel method - experimental methods - chemical reaction method - chemical reduction method - complex de - complex method - solubility reduction method - sol gel method.

3. MELT AND VAPOUR TECHNIQUES:

Growth from melt – Bridgman, Czochralski, zone melting, Verneuil techniques - physical vapour deposition - flux growth - chemical vapour deposition - chemical vapour transport - hydrothermal growth - epitaxial growth.

4. OPTICAL STUDIES:

Atomic absorption spectroscopy - UV - Visible - NIR spectroscopy - Experimental set ups for Fourier Transform Infrared analysis, FT - Raman vibrational spectroscopy - Illustrations with selected crystals - Nonlinear optical phenomenon (qualitative) - Kurtz powder SHG method - photoconductivity and schematic set up for measurements - negative photoconductivity.

5. CRYSTAL CHARACTERIZATION:

Thermal analysis - methods of thermal analysis - thermogravimetric analysis (TGA) - Differential thermal analysis (DTA) - Differential Scanning Calorimetry (DSC) - Mechanical studies - methods of hardness testing (qualitative) - Vickers hardness testing - correlation of microhardness with other properties - estimation of hardness number and work hardening coefficient (n) - dielectric studies - dielectric constant and dielectric loss measurements.

BOOKS FOR STUDY AND REFERENCE:

1. Crystal growth processes by James Coble Brice, John Wiley and Sons, New York.(1986)

2. The growth of crystals from liquids by John Chadwick Brice North - Holland Pub. Co., (1973)

3. Crystal growth by Harold Eugene Buckley, John Wiley and Sons, New York(1951)

4. Crystal growth by Brian R. Pamplin, 2nd Edition, Pergamon, (1980)

5. Crystals in Gels and Liesegang Rings by Heinz K. Henisch, Cambridge University Press(2005)

6. Thermal Analysis: Theory and Applications by R. T. Sane, Jagdish K. Ghadge, Quest Publications, (1997)

7. Handbook of Nonlinear Optical Crystals by Valentin G. Dmitriev, Gagik G. Gurzadyan, David N. Nikogosyan, 3rd Edition, Springer, (2010)

8. Photoconductivity: Art, Science, and Technology by N. V. Joshi, Marcel Dekker, (1990)

9. Crystal growth Process and Methods by Santhanaraghavan P. and Ramasamy P., KRU Publications, Kumbakonam. (2000)

10. Springer Handbook of Crystal Growth by Govindhan Dhanaraj, Kullaiah Byrappa, Vishwanath Prasad, Springer, (2010)

11. Advances in technologically important crystals by Binay Kumar, R. P. Tandon, University of Delhi. Dept. of Physics and Astrophysics, Macmillan, (2007)

PH 1157: ADVANCES IN MATERIAL SCIENCE

Paper -III

PART- I TECHNIQUES

Semester I **Credits: 6**

Category: Elective Subject (ES) **Hours/Week: 6**

Unit 1: The technology of epitaxy advantages of epitaxial growth - epitaxial techniques liquid phase epitaxy - apparatus tipping, dipping, sliding - principles of LPE growth vapour - phase epitaxy principles - operation technology - mocvd, lbe, cbe, ale-quasi crystals/ quasicrystalline state, high dimensional crystallography, sample characterization, modelling the atomic structure of crystals, phase transformation.

Unit 2: Nanopowders and nanomaterials and nanoelectronics - preparation techniques - application of nanomaterials - Carbon age-types of nanotubes - formation of nanotubes - carbon nanotubes - properties and uses of nanotubes optics, photonics - interaction of light and nano materials - photon trapping and plasmons - dielectric constant and polarization - refractive index - nanoelectronics - tools of micro and nanofabrication - optical lithography - electron beam lithography - atomic beam lithography - high electron mobility - carbon nanotubes transistors - future applications.

Unit 3: Thin film applications- materials selection-design fabrication of thin film registor, capacitor, diode, transistor, transparent conducting oxide thin films- semi conducting thin

films- thin film solar cell-Cds and Cu2S based solar cells CdS-Cu2S and cds/CulnSe2 solar cells- thin film mask blanks for VLSI-thin film sensors for gas detection –thin film deposition techniques- characteristic studies.

UNIT 4: Laser principles and applications- fiber optics- applications- Raman spectroscopy- ultrasonic means of communication- Non-destructive Testing- dispersive and colloidal effects of ultrasonic- separation of mixtures by ultrasonic cutting and machinery of hand materials – applications

UNIT 5: Instrumental Analysis-Differential Scanning Calorimeter (DSC) Electron Energy Loss Spectroscopy (EELS), SImS- Scanning Electron Microscope (SEM)- Transmission Electron Microscopy (TEM)- atomic forcemicroscopy (AFM)- Scanning Tunneling Microscopy (STM) Reflection Electron Microscopy(REM)- crystallographic analysis in the TEM- HRTEM- Convergent Beam Electron Diffraction analysis(CBED) applications- photoluminescense spectroscopy- plasma emission spectroscopy- applications.

BOOKS FOR STUDY:

1. Structure and properties of solid state materials by B. Viswanathan, 2nd Edition, Alpha Science International, (2006).

2. Nano - The essentials by T.Pradeep, Tata McGraw - Hill publishing company limited (2007).

BOOKS FOR REFERENCE:

1. Nanocomposite Science and Technology by Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, John Wiley & Sons, (2006)

2. Nanoparticles: From Theory to Application by Günter Schmid, 2nd Edition, John Wiley & Sons, (2011)

3. Nanotechnology: Principles And Practices by Sulabha K.Kulkarni, Capital publishing company (2007).

4. Nanomaterials by B. Viswanathan, , Narosa Publishing House Pvt. Ltd., New Delhi, (2009)

5. Nano Materials by A. K. Bandyopadhyay, 2nd Edition, New Age International Publishers Ltd., New Delhi, (2007).

6. Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films by C. R. Brundle, Charles A. Evans, Shaun Wilson, Butterworth - Heinemann publishers (1992).

7. Introduction to nanotechnology by Charles P.Poole, Frank J. Owens, John Wiley & Sons publication (2003).

8. Synthesis of inorganic materials by Ulrich Schubert, Nicola Husing, 3rd Edition, John Wiley & Sons, (2012)

9. Cluster beam synthesis of nanostructured materials by Paolo Milani, Salvatore Iannotta, Springer, (1999).