BHARATHIDASAN UNIVERSITY
TIRUCHIRAPPALLI – 620 024

M. Phil., PHYSICS (FT / PT) PROGRAMME
(For the candidates to be admitted from the academic year 2007-2008 onwards)

Semester I

	Title of the Course	Marks			Credits
		IA	UE	Total	
Course -I	Research Methodology	25	75	100	4
Course - II	Advanced Quantum Theory	25	75	100	4
Course- III	Electronics and Instrumentation	25	75	100	4

Semester II

Course – IV	Elective (Any one)	25	75	100	4

1. Nonlinear Dynamics
2. Advanced Materials
3. Crystal Growth and Thin Film Physics
4. Molecular Biophysics and X– ray Crystallography

Dissertation and Viva-Voce Viva Voce 50 marks Dissertation 150 marks	200(150+50)	8

QUESTION PAPER PATTERN (Course I – IV)

Part - A: Two questions from each unit (without choice). Each question carries 2 marks. (10 x 2 = 20)

Part – B: One "EITHER OR" questions from each unit Each question carries 5 marks (5 x5 = 25).

Part – C: One question from each unit. Each question carries 10 marks. The candidate has to answer three questions out of the five questions (3 x 10 = 30)

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI 620 024

M. PHIL PHYSICS

COURSE I : RESEARCH METHODOLOGY

Unit 1: Working on a Research Problem

Scientific research – aim and motivation – Principles and ethics - Identification of research problem – Determining the mode of attack – Current status – Literature survey – Abstraction of a research paper - Access using internet web tools – Email – Impact and usefulness of the research problem – Role of research guide – Guidance and rapport - Preparation and presentation of scientific reports ; need and methods – ppt and poster –Writing of synopsis and dissertation and thesis.

Unit 2: Mathematical Methods

Hypergeometric Function – Confluent Hypergeometric function – Mathieu Function – Elliptic Functions and Elliptic integrals – Perturbation Methods – Nondegenerate and degenerate perturbation methods – Examples – The Binomial, Poisson and Gaussian Distributions – General properties – The central limit theorem – Fitting experimental data – Numerical solution of partial differential equations : Explicit and implicit finite difference schemes to Heat equation - Explicit and implicit methods for the wave equation – Finite difference schemes for Laplace equation

Unit 3: Data Analysis

Introduction – Statistical description of data (mean, variance, skewness, median, mode) – Distributions (Student's t-test, F-test, Chi-square test), Correlation (linear and nonparametric/rank) ; Modeling Data: Least squares, Fitting data – Nonlinear models – Surrogate analysis.

Unit 4: High Performance Computing

High Performance Computing (HPC) basics – Elements of Fortran 90/95 – Constants and Variables – Arithmetic Expressions – I/O statements – Logical expression – Conditional and control statements – Arrays – Function and Subroutines – Format statements – Advanced Features: Procedures, Modules, Recursive functions and Generic Procedures - Application Software and Libraries : MATLAB, MATHEMATICA, GNUPLOT, LATEX, LAPACK, BLAS and FFTW (Basics only).

Unit 5: Advanced Analytical Techniques

Single crystal and powder diffraction – Diffractometers – FT-IR, Raman and UV – Visible Spectrometers - Photo luminescence – Light, matter interaction – Photo reflectance – Electronic transitions – Analytical Technique - Principles of SEM, TEM, EDAX, AFM, EPMA – Instrumentation – Sample preparation – Analysis of materials – Study of dislocations –Ion implantation uses

BOOKS FOR STUDY AND REFERENCE :

Relevant Chapters in

Unit 1 :

1. J. Anderson, B.H. Durston & M. Poole, Thesis and Assignment Writing Wiley Eastern , Delhi (1977).
2. Rajammal Devadas, Handbook of Methodology of Research, R.M.M. Vidyalaya Press (1976).
3. Internet : An Introduction, CI Systems School of Computing, Jaipur, Tata McGraw Hill, New Delhi (1999)

Unit 2 :

1. J. Mathews and R..L. Walker, Mathematical Methods of Physics (Pearson Education, New Delhi, (2004).

Units 3 & 4 :

1. Troy Baer, An Introduction to FORTRAN 90, Ohio Supercomputer Center, Columbus, OH, USA, Internet Tutorial URL: http://oscinfo.osc.edu/training/f90/html/bsld.002.html.
2. Ananth Grama, et. al., Introduction to Parallel Computing, Pearson Education, Ltd., Second Edition, 2004.
3. V. Rajaraman and C. Siva Ram Murthy, Parallel Computers—architecture And Programming, Prentice Hall of India.
4. William H. Press, Saul A. Teukolsky, William Vetterling, and Brian P. Flannery, Numerical Recipes: The Art of Scientific Computing (Cambridge University Press, 2007).

Unit 5 :

1. M. William and D. Steve, Instrumental Methods of Analysis (CBS Publishers, New Delhi, 1986).

COURSE II : ADVANCED QUANTUM THEORY

Unit 1 : Symmetry in Quantum Mechanics

Space and time displacements : Unitary displacement operator – Equation of motion – Symmetry and degeneracy - Matrix elements for displacedstates – Group concept – Time displacement – The groups and generators of U(n) and SU(n) - The SU(3) Group - Space inversion – Unitary inversion operator – Time reversal, antilinear and antiunitary operators.

Unit 2 : Identical Particles

Symmetric and anti-symmetric wave functions – Symmetry group – Distinguishability of identical particles – The exclusion principle - Exchange degeneracy – The Slater determinants – Examples – Helium atom, Hydrogen atom, the Van-der Waals interaction - Spin matrices and eigen functions – Electron spin function – Spin function for three electrons.

Unit 3 : Path Integral Formulation of Quantum Theory

The path integral basics – Path integral evaluation of the free particle propagator – Equivalence to Schrodinger equation – Derivation of path integral – The Landau levels – The Berry phase – Imaginary time formulation

Unit 4 : Quantum Statistical Mechanics

Review of phase transitions: First kind and second kind – Evaluation of partition functions – Bragg – Williams Approximation, Fowler – Guggenheim Approximation – Krkwood method - 1 dimensional Ising model – Brief introduction to higher dimensional Ising models – Order and disorder in alloys – Structural phase change

Unit 5 : Quantum Computing

Review of Binary number system and logic gates – Turing machines and complexity classes – Qubits and quantum logic gates: single qubit logic gate matrices, computing functions, - Euclid's algorithm – Periodicity of a sequence – Factoring an integer – Quantum search algorithms: The Deutsch – Jozsa algorithm and Schur's algorithm.

BOOKS FOR STUDY AND REFERENCE:

Relevant Chapters in

1. L.I. Schiff, Quantum Mechanics (Mc Graw- Hill, Singapore, 1995) IInd edition.
2. J.J. Sakurai, Modern Quantum Mechanics (Addison – Wesley, Massachusetts, 1999).
3. W. Greiner, Quantum Mechanics: An Introduction (Springer, Berlin, 1994).
4. R.L.Liboff, Introductory Quantum Mechanics (Pearson Education, New Delhi, 2003).
5. R.P. Feynman, R. B. Leighton, and M. Sands, Feynan Lectures on Physics, (Addison – Wesley, Massachusetts, 1999).
6. B.K.Agarwal and M.Eisner, Statistical Mechanics (New Age Publisher, New Delhi, 1988).
7. R.Shankar, Principles of Quantum Mechanics (Plenum Press, New York, 1994).

COURSE III : ELECTRONICS AND INSTRUMENTATION

Unit 1 : Transducers and Signal Conditioning

Basic measurement system – Classification of transducers – Transducers in instrumentation and control systems – Selection – Types – Strain gauge – Variable resistance – Capacitive – Inductive – Potentiometric resistance type – Piezoelectric – LVDT – Thermistors – Thermocouple – Pyrometers – Solar Batteries – Differential Instrumentation amplifier and applications – Chopped and modulated dc amplifier.

Unit 2 : Data Acquisition , Conversion and Transmission

DAC – ADC using Ics - Data Acquisition System (DAS) – Signal conditioning of the inputs – Single channel DAS – Multichannel DAS – Sensors based computer data system – Data transmission system – Digital modulation – Pulse code format – Modems – Phase – lock loops – frequency to voltage converter – Voltage to frequency converter – Data loggers.

Unit 3 : Electronic Measuring Instruments

AC Bridges and their applications – Maxwell bridge, Hay bridge – Anderson bridge - Digital multimeter – Digital frequency meter – Digital measurement of time –Digital phase meter – Digital capacitance meter – LCR Meter.

Unit 4 : Electronic Control Instruments

Advantage of electronic control of devices – DC motor speed control – Over voltage and over load protection of DC motors – Temperature control – Illumination control – Battery operated inverter circuit using power transistor.

Unit 5 : Oscilloscopes and Analyzers

CRO – Construction – Deflection schemes – Working details of CRO – Application of CRO – Special Oscilloscope – Storage Oscilloscope - Digital Storage Oscilloscope (DSO) Signal Generators - Q Meter – Measurement methods – Wave analyzers – Frequency selective wave analyzer –Spectrum analyzer.

BOOKS FOR STUDY AND REFERENCE :

Relevant Chapters in

1. S.K. Bhattacharya, and S. Chatterjee, Industrial Electronics and Control (Tata McGraw Hill, New Delhi, 1995).
2. H.S. Kalsi, Electronic Instrumentation (Tata McGraw Hill, New Delhi, 1995).
3. N. Talbar, Electronics and Instrumentation (Dhanpat Rai and Sons, New Delhi, 2000).
4. D.A. Bell, Electronic Instrumentation and Measurements (Prentice Hall, New Delhi, 2003).
5. A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, (Prentice – Hall of India, New Delhi, 1995).

ELECTIVE - 1 : NONLINEAR DYNAMICS

Unit 1 : Linear and Nonlinear Systems

Linear and nonlinear forces –Nonlinear dynamical systems – Effects of nonlinearity – Phase space – Liouville theorem – Solution of damped and forced linear oscillator – Resonance phenomenon – Duffing oscillator – Jump phenomenon.

Unit 2 : Fixed Points and Stability Analysis

Stable and unstable fixed points – Classification of fixed points in first and second order systems – Limit cycle motion – Bifurcations : Saddle node, Pitchfork, Transcritical and Hopf bifurcations.

Unit 3 : Bifurcation and Chaos

Logistic map : Stability of period – 1 and 2 fixed points – period doubling phenomenon – Onset of chaos – Bifurcation diagram – Different routes to chaos : Period doubling route, quasiperiodic route and intermittency route – Necessary conditions for chaos.

Unit 4 : Fractals

Self-similarity - Self-similarity in Henon attractor – Properties of fractals – Examples of fractals – Fractal dimenstion – construction and properties of middle-third cantor set, Koch curve and sperpinski trainagle

Unit 5 : Soliton and Integrability

Complete Integrability of finite dimensional systems – Painleve analysis to detect Integrability - Linear and nonlinear waves – Conidial and solitary waves _ John Scott Russel's observation of solitary wave – K-dv equation – Fermi – Pasta Ulam Problem – Numerical experiment of Zabusky and Kruskal – Soliton – Lax pair – Inverse Scattering Transform method for K-dv equation – Other soliton equations – Applications

BOOKS FOR STUDY AND REFERENCE :

Relevant Chapters in

1. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics : Integrability Chaos and Patterns (Springer-Verlag, Berlin, 2003).
2. E.Ott. Chaos in Dynamical Systmes (Cambridge University Press, Cambridge, 1993).
3. H. G. Schuster : Deterministic Chaos (Verlag, Weintein, 1988).
4. H. O. Peitgen, P.H. Richter, The Beauty of Fractals (Springer, Berlin, 1986).
5. P. G. Drazin and R.S. Johnson, Solitons : (Cambridge University Press, Cambridge, 1985).
6. M.J. Ablowitz and P.A. Clarkson, Solitons, Nonlinear Evolution Equations and Inverse Scattering (Cambridge University Press, Cambridge, 1991).

ELECTIVE - 2 : ADVANCED MATERIALS

Unit 1 : Synthesis of Nanomaterials

Nanomaterials and various preparation techniques – Phenomenology of nanostructure formation – high energy ball milling and mechanical attrition – Mechanism of grain size reduction – Property - microstructure relationship – Phase stability at elevated temperatures – Severe plastic deformation – Cold rolling – Friction induced surface modifications.

Unit 2 : Quantum Concepts of Nano-Structures

General properties and growth of Nano-structures – Band engineering – Doped hetero – structures – Infinite well-Finite well – Low dimensional systems – Two and three dimensional potential wells - Nano - particles through homogeneous and heterogeneous nucleation – Synthesis of nano –particles – metallic – semiconductor and oxide Nano – particles – Kinetically confined synthesis of nanoparticles – epitaxial core – shell nanoparticles

Unit 3 : One Dimensional Nano-structures : (Nano-wires and Nano-rods)

Spontaneous growth of nano – wires and nano – rods – Condensation growths – VLS and SLS growth – Template based synthesis – Electrochemical and electrophoric deposition – Template filling – Electro spinning- Fundamentals of film growth, vacuum Science – PVD, MBE, CVD and ALD, superlattices – Langmuir –Blodgett films – Electrochemical deposition – Sol – Gel films.

Unit 4 : Foundation of Nanophotonics

Photons and Electrons : Similarities and differences – Free space propagation – Confinement of Photons and electrons – Tunneling – Band gap – Nanoscale optical interactions – Nanoscale confinement of electronic interactions – Near-field optics - Near-field microscopy – Study of quantum data – Single molecule spectroscopy – Nonlinear optical process – Time and space resolved studies on nanoscale dynamics.

Unit 5 : Photonic Crystals and Nanocomposites

Basic concepts –Theoretical modeling of photonic crystals – Methods of fabrication - Photonic crystal optical circuitry – Nonlinear photonic crystals - Photonic crystal fibres – Optical communication – Sensors – Nano-composite wave guides –Laser paints – Nanocomposites for optoelectronics polymer – Dispersed liquid crystals

BOOK FOR STUDY AND REFERENCE :

Relevant Chapters in

1. H. Davies, The Physics of Low- dimensional Semi conductors Cambridge University Press, Cambridge 1998)
2. Gao, Nano structures and Nano-materials (Imperial College Press, London, 2004)
3. N. Prasad, Nanophotonics, (John- Wiley & Sons, New Jersey, 2004)
4. F. Graham Smith and T. A. King Optics and Photonics : An Introduction, (John Wiley & Sons, New York, 2001)

ELECTIVE 3 : CRYSTAL GROWTH AND THIN FILM PHYSICS

Unit 1 : Basics of Crystal Growth and Thin Film

Nucleation – Different kinds of nucleation – Formation of crystal nucleus – Energy formation of a nucleus – spherical and cylindrical nucleus – Thin films –Thermodynamics of nucleation - Growth kinetics of Thin film – Crystal growth process in thin films - Epitaxial growth of thin films (basic concept only).

Unit 2: Solution Growth Techniques

Low temperature solution growth : Solution – Solubility and supersolubility – Expression of supersaturation – Miers T-C diagram – constant temperature bath and crystallizer – Seed preparation and mounting – Slow cooling and solvent evaporation methods – Gel growth – various types – Structure of gel – Importance of gel technique – Chemical reaction method – single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Solubility reduction method – Advantages of gel method – High temperature solution growth – Hydrothermal growth – Flux growth.

Unit 3: Melt and Vapour Growth Techniques

Phase diagram and phase rules (basic concept) – Melt technique – Bridgman technique – Basic process – Various crucible design – Thermal consideration – Vertical Bridgman technique – Experimental arrangement - Czochralski technique – Experimental arrangement – Growth process – Growth rate – Liquid Encapsulated Czochralski technique - Verneuil method – Vapour growth – Basics of vapour growth – Physical vapour deposition (PVD) – Chemical vapour depostion (CVD) - Chemical vapour transport (CVT) – Experimental arrangement.

Unit 4: Thin Film Preparation Techniques

Thin films – Introduction to vacuum technology – Deposition techniques - Physical methods – Resistance heating – Electron beam method - Sputtering – Reactive sputtering – RF sputtering - Pulsed laser deposition – Chemical methods – Chemical bath deposition – Electrodeposition – Spray pyrolysis deposition.

Unit 5 : Characterization Techniques

Characterization using X-ray powder method - Single Crystal methods -Spectroscopic methods : FTIR, Raman, SEM, Energy Depressive, X-ray (EDX), U.V. Visible - Band gap energy calculation – Etching - Chemical etching – Thermal properties of crystals - Thermogrametric analysis (TGA), Differential thermogram (DTA) and Differential Scanning Calorimetry (DSC) – Vicker microhardness - Thin Film thickness measurement – Microbalance method – Optical interference method.

BOOK FOR STUDY AND REFERENCE :

Relevant Chapters in

1. J. C. Brice, Crystal Growth Processes, John Wiley and Sons, New York (1986).
2. P. Santhana Raghavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam, India (2001).
3. A. Goswami, Thin film Fundamental, New Age International (P) Ltd, New Delhi (2006).
4. M. Ohring, Materials science of Thin films, 2nd Edition, Academic press, Elsevier, New Delhi (2002).
5. H. H. Williard, L. L. Merritt, J. Dean, and F. A. Settle, Instrumental Methods of Analysis – Sixth Edition, CBS Publishers & Distributors, Delhi (1986).

ELECTIVE 4 : MOLECULAR BIOPHYSICS AND X– RAY CRYSTALLOGRAPHY

Unit 1 : Conformational Analysis of Proteins

Asymmetric carbon – Chirality – Fisher convention – L and D system - R-S system -Amino acids – Peptide bond – Rigid planar peptide – Cis and Trans configuration –Conformation-Torsion angles – Phi and Psi – Allowed conformation of a pair of linked peptide units –Steric hindrance – Hard sphere approximation – Contact criteria – Ramachandran diagram – Map for glycine and alanine residues – Conformational energy – Noncovalent forces – Description of various interactions by potential functions – Energy map – Minimisation of energy.

Unit 2 : Structure and Function of Carbohydrates

Classification – Nomencleature – L and D sugars – Monosaccharides – Stereoisomerism of sugars – Conformation of pyranoid rings – Disaccharides – Types of linkages in polysaccharides – Structure of maltose, cellobiose, lactose and laminarabiose – Ramachandran map for disacharides – Conformational energy map – Polysaccharides – Glycoproteins - Mucopolysaccharides .

Unit 3 : Structure and Function of Nucleic Acids

Conformations of monomer nucleosides and nucleotides – Structure of oligonucleotides – Base pairing and base stacking – Structure of DNA – Watson and Crick model – Variations in DNA structure – Polymorphism – A, B and Z DNA – Structure of RNA and tRNA – Genetic code - Protein biosynthesis – Globular proteins.

Unit 4 : Structure and Function of Proteins and Bioinformatics

Levels of structural organisation – Types of secondary structures – Helix – β sheet – Turns-Functions of Proteins – Classification of proteins into globular and fibrous - Structure of collagen and silk - kmef proteins- structure of Hemoglobin and myoglobin-Bioinformatics : Internet – Search engines – Biomolecular structural data bases : Protein structure database – PDB, SWISS-PROT - Nucleic acid database: GenBank, EMBOSS-Carbohydrate database: CCSD, Carb bank

Unit 5 : X-ray Crystallography

Crystal diffraction-Bragg's law - Reciprocal lattice- Structure factor-data collection - Data reduction - Wilson plot - Scale factor and temperature factor - Crystal structure determination-space group determination - Systematic absences - Phase problem - Method of solution-Patterson and Heavy atom method - Isomorphous and Anomalous scattering methods-Direct methods - Structure solution and refinement - R-factor-conformational analysis.

BOOKS FOR STUDY AND REFERENCE :

Relevant Chapters in

1. A. I. Lehninger, D. I. Nelson and M. M. Cox, Principles of Biochemsitry, CBS Publishers, New Delhi (1993).
2. L. Stryer, Biochemsitry, W. H. Freeman and Co., Newyork (1995).
3. G. E. Schulz and R. H. Schirmer, Principles of Protein Structure, Springer-Verlag (1984).
4. C. R. Cantor and P. R. Schimmel, Biophysical Chemistry : Part I, II and III : W. H. Freeman and Co. New York (1980).
5. V. S. R. Rao, P. K. Qasba, P. V. Balaji and R. Chandrasekaran Conformation of Carbohydrates Harwood Academic Publishers, Amsteerdam (1998).
6. P. Narayanan ,Essentials of Biophysics, New Age International (P) Ltd , Publishers (2000).
7. J. Drenth, Principles of Protein X-ray Crystallography Springer (1994).
8. V. Pattabhi and N. Gautham Biophysics, Narosa Publishing House (2004).
9. D.R. Westhead, J.H.Parish and R.M.Twyman, Instant notes Bioinformatics, Viva Books Private Ltd, New Delhi (2003)

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