ALBERT EINSTEIN SCHOOL OF PHYSICAL SCIENCES
ASSAM UNIVERSITY, SILCHAR
COURSE WORK SYLLABUS FOR Ph. D/M. Phil

Paper – 1: Research Methodology in Physical Sciences (School Level)

Credit: 04

UNIT –I:
Research: Meaning, objectives, types, approaches. Criteria of good research, research problems, research design. Review of literature: Meaning, objectives, principles and procedure. Report writing: Meaning, significance, types, techniques.

UNIT – II:
Quantitative methods of research: Methods of data collection – experimental data, field data, data from secondary sources. Relation between variables: correlation (both continuous & binary data), regression (both linear & non-linear) for two variables. Test of significance including one-way-anova. Errors and analysis of errors.

UNIT – III:
Computer application in research: Data analysis – use of software like Excel/Mat lab/Mathemetica/SPSS etc., Word processing – use of software like MS Word/LATEX/End Note etc., Data bases – use of software like MS Access/My SQL etc. Introduction to Computer Network: Network Protocol and topology. Computer simulations: Introduction to mathematical and simulation models, deterministic and stochastic simulation models, continuous and discrete simulation.

UNIT – IV:
Intellectual Property Rights (IPR) – patents, copyrights and related issues. Plagiarism: concept, software, legal aspects. National Science Policies.
Ethics in Research

Suggested readings:

1. Research Methodology-Methods and Techniques, New Age International, C. R. Kothari, 2nd Ed. (New Delhi), 2008.
2. Research Methodology: A step-by-step guide for beginners, SAGE Publications, Ranjit Kumar, 2005.
3. Mastering MATLAB by Duane C. Hanselman and Bruce L. Littlefield, 2011.
4. Queqeing system-Vol.2-D, Kleinrock, John Wiley & Sons Inc New York, 1976.
5. Computer Network by A. Tanebaum. Printice Hall Ind. Englewood cliffs N.J., 1981.
6. Data and computer communications by W. Stallings, Mc Millan Pub. Co. New York, 1976.

DEPARTMENT OF PHYSICS
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Paper-II: Physics (General)

Credit: 4

Unit I: Revolutionary concepts in Physics:

Quantum Mechanics,
Relativity - Special and General,
Statistical Mechanics

Unit II: Mathematical Techniques:

Selected topics in Mathematical Physics: Green Function, Second order partial differential equations(Laplace, Wave and Heat equations in two and three dimensions), Laplace and Fourier transforms, Complex analysis: Evaluation of Integrals, Symmetry groups SU(2) and O(3).

Unit III: Computational techniques:

Introduction to numerical methods and FORTRAN programming, direct solution of linear equations, interpolation, curve fitting, numerical integration and solution of differential equations, simple simulation.

Unit-IV: Experimental techniques:

Generation and measurement of vacuum;
Analytical Instruments: X-ray diffractometer, spectrometers (UV-Vis, FTIR), microscopes (SEM, TEM, AFM), Photometer

References:

1. M. G. Bowler's *Lectures on Statistical Mechanics*.
2. Introduction to Modern Statistical Mechanics , Chandler
3. Murry R Speigel, Complex variables Mc Graw Hill
4. A W Joshi, Elements of Group Theory for Physicists New Age International
5. Fortran 77 and Numerical methods C Xavier, New Age
6. Numerical methods E. Balagurusamy, Tata McGraw Hill
7. Numerical recopies in Fortran W.H. Press et. al, Cambridge University Press
   Murry R Speigel, Vector Analysis Mc Graw Hill
8. Introduction of Solid State Physics by C Kittel
9. Solid State Physics by N W Aschroft and N D Marmin

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Paper-III: Physics (Advance)

Paper-III(A): Astrophysics & Cosmology

Credit: 4

UNIT I: OBSERVATIONAL ASTRONOMY

Celestial sphere and co-ordinate system-Stellar Colour: Magnitude, spectral types- HR Diagram.

Telescopes and Observational techniques: Photometry- Spectrometry and Polarimetry-Optical,

X-ray, UV, Radio Astronomy

UNIT II: STELLAR EVOLUTION

Star Formation in Molecular clouds, Jean's Condition.

Stellar Evolution: Pre-main sequence contraction- Stars in main sequence; Nucleosynthesis-

Energy generation- p-p Chain Reaction-CNO-Cycle, Post main sequence evolution, Supernova,

late type stars, White Dwarf-Chandrasekhar's Limit, Neutron Stars and Pulsars, Black Holes.

UNIT III : General Theory of Relativity

Derivatives of Tensors - Covariant and Lie Derivatives. Christoffel symbol. Bianchi Identities.

Non-inertial frames, Principle of equivalence, Line element in GTR, Metric Tensors -- its relation with Christoffel Symbols, Geodesic motion of a massive and massless particle in an gravitational

field. Einstein Equation (derivation) -- Schewartzchild and Blackhole solutions.

UNIT IV: Cosmology

Standard Model of Cosmology,Early Universe, Radiation and Matter dominated era.

Problems of hot Big Bang Scenario, Inflationary paradigm -- solution to Big Bang problems.

Cosmic perturbation and large scale structure.

Late time acceleration -- Dark Energy

Recommended Books:

1. Classical Theory of Fields, Vol 2 – Landau and Lifshitz (Butterworth –Heinemann)
2. Gravitation and Cosmology – S Weinberg (John Wiley and Sons, UK)
3. Cosmolgy – Steven Weinberg (John wiley and Sons, UK)

4. The Physical Universe—An Introduction to Astrophysics – F Shu (University Science Books
Sausalite, California)
5. Fundamentals of Special and General Relativity –K D Krori (PHI Learning)

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Paper-III(B): Condensed Matter Physics

Credit: 4

UNIT I: Simulation Methods

Molecular Mechanics, Molecular Dynamics, Hückel method: Hückel determinant, Hückel molecular orbital, application (benzene, cyclobutadiene), Semiemperical methods : CNDO, INDO, MNDO, AM1, PM3, abinitio methods: Hartree Fock and post Hartree Fock

UNIT II: Density Functional Theory

Theoretical motivation, Basic concepts of DFT, Hohenberg-Kohn theorem, Kohn-Sham formalism, Exchange-correlation functional, Local density approximation (LDA), Generalized gradient approximation (GGA), Elementary idea of time dependent DFT.

UNIT III: Applications

Application of molecular simulation methods, molecular properties, charge density distribution in molecules, dipole moments, geometry optimization, intermolecular interactions,

chemical reactions, carbon nanostructures and other nano-materials, biomolecules: stability and

structure of nucleic acids, DNA and RNA and proteins, primary, secondary and tertiary structures of protein, enzymes.

UNIT IV: Experimental Techniques

Vacuum technology: Rotary pump, Diffusion pump, Turbo Molecular pump; Vacuum gauges: Pirani gauge, Penning gauge;

Characterization techniques: X-ray diffractometer, UV-Vis spectrometer, FTIR spectrometer; Surface enhanced Raman spectroscopy, NMR

Microscopy techniques: SEM, TEM, AFM

References:

1. Density Functional Theory of Atoms and Molecules
Robert G. Parr and Weitao Yang (Oxford Science Publications)

2. Electronic Structure and the Properties of Solids
The Physics of Chemical bond
Walter A. Harrison (Dover Publications)
3. Introduction of Solid State Physics by C Kittel
4. Solid State Physics by N W Aschroft and N D Marmin
5. Quantum Chemistry by Lavin
6. Essentials of Biophysics by P. Narayan (New Age International Publishers)

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Paper-III(C): Atmospheric Physics

Credit: 4

Unit I

Atmosphere: Origin of the atmosphere, Structure and composition of the atmosphere.

Atmospheric Thermodynamics: Application of thermodynamics in atmospheric processes, Adiabatic process, Potential temperature, Temperature lapse rate and inversion, Hydrostatic equation and atmospheric stability.

Unit II

Atmospheric Dynamics: Coordinate systems, Forces acting in atmospheric motion, Horizontal equation of motion, Vertical equation of motion, Thermal wind, Thermodynamic energy equation, The continuity equation.

Clouds and Precipitation: Different types of clouds, Formation of clouds, Cloud seeding, Different kinds of precipitation, Rainfall distribution pattern in Northeast India, Seasonal variation of rainfall.

Unit III

Monsoon Circulation: Origin and mechanism of Asiatic monsoon, Role of monsoon circulation on Indian agriculture. Some Important atmospheric circulation: El-Nino and La-Nina – mechanism of formation and impact on climate, Southern Oscillation, ENSO

Unit IV

Weather and climate: Climatic extremes - environmental implications, Climate of Northeast India, Global climate change and its impact on environment.

Satellite Meteorology: Introduction, Types of satellites, Meteorological satellites, Sensors for monitoring weather, Indian meteorological satellites.

References:

1. The Atmosphere: An introduction to Meteorology, Authors: Frederick K. Lutgens, (Emeritus)

Illinois Central College, Edward J. Tarbuck, Emeritus) Illinois Central College, Dennis Tasa, Illustrator

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Paper-III(D): Rare-Earth Spectroscopy and Optical Materials

Credit: 4

Unit I

Energy structures and dynamics of electronic transitions of rare-earth ions: Electronic states and coupling schemes, freeion interactions- reduced matrices representation of free –ion state, parameterization of free ion interaction. Crystal free interaction- empirical and theoretical evaluation of crystal field parameters and spectra analysis.

Unit II

Transition Intensities: Basic equations-electric and magnetic dipole operators, polarization selection rules, vibronic states. One photon transition within 4fnconfiguration, Modeling of 4fn- 4fn-15d spectra and transitions, two photon processes.

Unit III

Energy transfer mechanisms in rare –earths: Historical background, Energy diffusion in Up and down conversion, Up –conversion mechanisms in single ions and pair, Cross relaxation and photon avalanche process.

Unit IV

Material synthesis and optical characterization: Different processes in synthesis of optical materials, Spectroscopic and laser parameters: basic parameters (Absorption , emission cross-section, radiative lifetimes , branching ratios. etc.) and its determination by spectroscopic method.

References:

1. Spectroscopic properties of Rare Earths in Optical Materials, G Liu and B Jacquier(Eds),(Springer, 2005) and relevant references therein.

2. W M Steen ,Laser Material Processing 3rd Edition (Springer , 2005) and relevant references therein.

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Paper-III(E): Theoretical Physics

Credit: 4

Unit I

A preview of fundamental particles and their interactions.

Review of classical field theory : Lagrangian formulations for continuous system and fields. Noether's theorem.

Introduction to field quantization : Canonical quantizations of scalar, Spinor and gauge fields.

Unit II

Introduction to Gauge theory of fundamental interactions: Feynman diagrams in Momentum space and its applications in QED.

Parton model, Deep-Inelastic Scattering (DIS), QCD-evolution equations.

Standard model of electroweak interaction, neutrino masses and mixing angles.

Unit III

Single quantum systems, states, superposition of states, reversible unitary evolution, observable, measurement, composite systems, measurement on one system, completely positive maps, decoherence

Unit IV

Use of Quantum laws in information transfer: Quantum copier, Secret key distillation, Quantum teleportation, Quantum Fourier Transform, Grover's Algorithm, Shor's Algorithm, Quantum error correcting code, Distillation protocol, Bound entanglement.

Reference:

1. M. Nielsen, I. Chuang Quantum Computation and Quantum Information (Cambridge University Press, Cambridge, 2009)

2. D. Bouwmeester, A. Ekert, A. Zeilinger (eds.) The Physics of Quantum Information (Springer,
Berlin, 2000)

3. G. Alber et. al. Quantum Information (Springer, Berlin, 2001)

4. A. Peres Quantum Theory: Concepts and Methods (Kluwer, Dordrecht, 1995)

5. W Greiner and J Reinhardt, Field Quantization (Springer, Berlin, 1996)

6. D H Perkins, Introduction to High Energy Physics (Cambridge University Press, Cambridge, 2000)

7. F Halzen and A D Martin, Quarks and Leptons (John Wiley, 1984)

8. T P Cheng and L F Li, Gauge Theory of elementary particle physics (Clarendon Press, Oxford,2000)

9. C Guinti and C W Kim, Fundamentals of Neutrino Physics and Astrophysics, (Oxford UniversityPress, Oxford, 2007)