Pre-Ph.D. Syllabus

PHYSICS

UTKAL UNIVERSITY

DEPARTMENT OF PHYSICS
UTKAL UNIVERSITY
2016

Mahapatra
Head of the Post Graduate
Department of Physics
Utkal University
Bhubaneswar-751004

Pre Ph.D. Physics Syllabus
Utkal University
2016

Pre-Ph.D. Course work

Pre-Ph.D. course work is of one semester duration.

The candidate has to secure at least 50% in each paper to pass the examination.

The course consists of the four papers, as follows:

Paper I- Elective: (100 marks) (The student is to select one of the offered subjects as a supplement to courses already taken) Advanced Particle Physics/ or Advanced Condensed Matter Physics

Paper II- (100 marks) Nuclear, Particle Physics and Solid State Physics Experiments; Research Methodology.

Paper III– (100 marks) IT and Research Methodology

Paper IV- (100 marks) Seminar presentation and Viva-voce Examination

Paper I

Elective : (Advanced Particle Physics / or Advanced Condensed Matter Physics) 100marks

ADVANCED PARTICLE PHYSICS

Charge independence of Nuclear interactions, Two nucleon state vector, Isospin, Isospin nonconserving processes, Strangeness and Hypercharge, Charm, Bottom and top quantum numbers, Lepton and Baryon number conservation, Yukawa's theory, Neutrinos, Parity, Parity conservation and nonconservation, Time reversal, Consequences of time reversal invariance, Charge conjugation, G-parity, Statement of CPT theorem and its consequences, Proof of equality of mass and life time for particle and anti particle. Mesons and Baryons, Unitary Symmetry and the classification of state, Hadrons as SU (3) multiplets, Higher dimensional irreducible representations, Properties of representations, SU(3) flavor, Gell-Mann-Okubo mass formula for Baryons and Mesons, Coleman-Glashow relation, Successes of Quark model, Magnetic moment of baryons, Baryon wave functions. Charm, Bottom and top quarks.

Quantum Electrodynamics (QED) :
Vacuum expectation value of operators, Propagators involving scalar, spinor and vector fields, The S-matrix expansion, Time ordered product, Normal ordered product, Wick's theorem Feynman diagrams in configuration and momentum space, First order terms in S-matrix,

Feynman diagrams for Compton scattering, Electron- electron scattering, closed loop diagrams, Feynman rules for QED, QED Lagrangian and gauge invariance, Differential cross section for Compton Scattering, Bhabha scattering.
Weak Interactions: Lepton decays; Leptonic, semileptonic and hadronic weak decays, Intermediate Vector Boson, Weak Interaction Lagrangian, Neutral current., Higgs boson.
Strong Interactions: Quarks and Gluons, Colour hypothesis, colour SU(3), Evidence of colour.

Text Books :

Introduction of High Energy Physics- D.H. Perkins (Cambridge University Press)
Elementary Particle Physics- D.J.Griffiths (Wiley)
Elementary Particles- I.J. Hughes (Cambridge University Press)
Quantum Field Theory –F. Mandl and G.Shaw (Wiley)

Reference Books:

Modern Elementary Particle Physics - G. Kane (Addison Wesley)
Concept of Particle Physics - V. Weisskopf and G.K. Gottfried (Oxford University Press)
Quarks & Leptons - F. Halzen & A.D. Martin (Wiley)
Quantum Field Theory - C.Itzyksen and J-B. Zuber (Dover)
Quantum Field Theory – M. E. Peskin and D. V. Shroeder (Westview Press)
Quantum Field Theory – L. H. Ryder (Cambridge University Press)

OR

ADVANCED CONDENSED MATTER PHYSICS 100 marks

Phonons and their interaction :

Hamiltonian for lattice vibrations in the harmonic approximation, Normal modes of the system and quantization of lattice vibrations – phonons.
Electron-phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction, BCS theory.

Bands theory:

Wave equation for an electron in a periodic potential, Bloch functions, Brillouin zones, ε-k diagram under free electron approximation, Nearly free electron approximation, Diffraction of electrons by lattice planes and opening of gap in ε-k diagram. Effective mass of electrons in crystals, Holes, Tight binding approximation

Fermi Surface:

Fermi surface and its role in the study of thermal, electrical, magnetic and optical properties, Construction of Fermi surface, Experimental methods of study of Fermi surface, Cyclotron Resonance, de Hass van Alphen effect.

Electron Interaction:

Scattering of electrons near the Fermi surface, Perturbation formulation, Dielectric function of an interacting electron gas (Lindhard's expression), Static screening, Screened impurity, Kohn effect, Friedel Oscillations and sum rule, Dielectric constant of semiconductor, Plasma oscillations.

Electron Transport in metals:

The Boltzmann equation, Electrical conductivity, General Transport coefficients, Thermal conductivity, Thermoelectric effect, Hall effect, Elementary ideas on Quantum Hall Effect, Magneto resistance, Elementary ideas on Giant magneto-resistance and Colossal magneto resistance.

Text Books

Principles of the Theory of Solids – J.M. Ziman Cambridge University Press)

Introduction to Solid State Physics – C. Kittel (Wiley)

Advanced Solid State Physics – Philip Phillips (Overseas Press, India Pvt. Ltd.)

Reference Books

Introduction to Modern Solid State Physics - Yuri M. Galperin (CreateSpace Independent Publishing Platform)

Solid State Physics – N. W. Aschroft and N. Mermin Brooks/ Cole)

Introduction to Solids – L. V. Azaroff (McGraw Hill)

Elementary Solid State Physics – M. Ali Omar (Addison Wesley)

Principles of Condensed Matter Physics – P. M. Chaikin and T. C. Lubensky (Foundation Books)

Solid State Physics, Essential Concepts - David W. Snoke (Pearson Education)

Paper- II **100 marks**

Nuclear, Particle Physics and Solid State Physics Experiments :

Besides the laboratories in the Department, some experiments are carried out at other Research Laboratories, such as CIPET.

Basic exposure to : Power supplies; PMT; Detectors; Counters; X-Ray Diffraction techniques; Thin film coating; Different characterizations.

Experiments:

1. Determination of the Optical Properties of various thin film and bulk samples by UV-Visible Spectrophotometer.
2. Determination of spectroscopic splitting of DPPH using ESR technique.
3. Calibration of the magnetic field using Hall effect set up and determine Hall coefficient.
4. Study of Nuclear Magnetic Resonance. 14
5. Study of thermoelectric power generation in the given sample. 4
6. Study the mono-atomic and di-atomic lattice using the given LC-set up. 5
7. Determine the forbidden energy gap of a given semiconductor by using a PN-junction diode.
8. Determine the band gap of the given semiconductor using four-probe resistivity set up.7
9. Study of ultrasonic waves in solids.
10. Study of Ultrasonic waves in liquid at different frequencies.

11. Determine the magnetic susceptibility of copper sulphate by using Guoy balance.
12. Study the magnetic characteristics of the given sample using Hysteresis loop tracer.
13. Photo conductivity measurement of the given substance .
14. Holography study of the given samples.
15. Determine the Magneto-resistance of the given sample
16. Determination of the Curie temperature of the given ferromagnetic substance.
17. Thermal analysis of the samples by using TGA/DSC instrument. (CIPET)
18. Surface analysis study of samples using Scanning Electron Microscopy. (CIPET)
19. Morphology and imaging the internal structure of samples by Transmission Electron Microscopy (TEM) (CIPET)
20. Structural analysis study of samples by X-ray Diffractometer. (Utkal University)
21. Surface roughness study of the given samples by Atomic Force Microscopy (AFM).
22. Determination of the mass of electron using Compton scattering experiment.
23. Determination of the linear absorption coefficient or attenuation constant of β-ray using GM counter.
24. Determinatin of Lande's g-factor for a given sample using ESR apparatus in M Hz range
25. Study of gamma ray spectrum for the supplied source and determination of the resolving power of the spectrometer
26. Calibration by using gamma ray from standard the standard sources and determination of the energy of the unknown supplied source

Thin film preparation techniques, thermal evaporation, rf sputtering, magnetron sputtering, pulsed laser deposition, ion bean sputtering, High vacuum techniques

Reference Books:
Experiments in Modern Physics – A.C. Mellisinos and J. Napolitano (Academic Press)
Techniques for Nuclear and Particle Physics Experiments – W.A. Leo (Springer India)

Paper-III **100 marks**

IT & RESEARCH METHODOLOGY

Basics of data encoding and storage; Machine architecture and machine language;
Operating systems; Advantages of Linux, Linux commands, Vim and Emacs editors for programming,
LaTeX for scientific manuscript preparation, GNU plot. Curve fitting,
Familiarization with MATHEMATICA and MATLAB
Programming languages: Introduction to programming languages, F77, C, C++
Programming with FORTAN: Programme solving on computers – algorithm and flow charts in FORTAN 77 data types, expressions and statements, input/output commands, sub programmes,
- Errors in numerical calculations
- Numerical linear algebra, eigenvalues and eigenvectors

- Interpolation techniques
- Generation and use of random numbers
- Sorting and searching
- Differentiation and Integration (including Monte Carlo techniquees)
- Root finding algorithms
- Optimization, extrema of many variable functions
- ODE's and PDE's : including FET and finite difference methods, integral equations
- Solution of Quantum Mechanical problems
- Solution of nonlinear differential equations
- Monte Carlo techniques and simulations

Reference Books:

1. Computer Science , an overview - J.G. Brookshear and D. Bryslow (Pearson)
2. Fundamentals of Computers – V. Rajaraman (Prentice Hall, India)
3. Fortran 77 and Numerical methods – C. Xavier (New Age International)
4. Programming and Computing with FORTRAN 77/90 – P.S. Grover (Allied Publishers)
5. Elements of Parallel Processing - V. Rajaraman (Prentice Hall)
6. FORTRAN 77 - R.N. Reddy & C.A. Ziegler (Jaico Book)
7. Wolfram- Mathematica Book (Wolfram Products)
8. W. H. Press, Saul A. Teukolsky, William T. Vetterling – Numerical Recipe (Cambridge University Press)

Research Methodology

Paper IV **100 Marks**

The candidate has to choose an approved topic for dissertation work under a recognized guide.

SEMINAR PRESENTATION AND VIVA-VOCE EXAMINATION.