SYLLABUS OF COURSE WORK FOR DOCTOR OF PHILOSOPHY

Ph. D. (Science)

2018

Department of Physics

(Under Faculty Council of Science)

DIAMOND HARBOUR WOMEN`S UNIVERSITY

SYLLABUS OF Ph.D. (Sc.) COURSE WORK

Department of Physics

DIAMOND HARBOUR WOMEN`S UNIVERSITY

Six - Months, One - Semesters Ph.D. Course Work in Physics: Grand Total Marks - 200

Paper Code	Paper Name	Full Marks	Periods/Week (in Hrs)
PHY/PhD/CP/01	Research Methodology	50	02
PHY/PhD/CP/02	Review Work and Presentation	50	02
PHY/PhD/EP/03	Elective Paper	50	02
PHY/PhD/EP/04	Elective Paper	50	02
	Total =	200	08

Compulsory Papers: PHY/PhD/CP/01 & PHY/PhD/CP/02

Elective Papers: Students are free to choose **Two** Elective Papers, one from each group from the following list which will be offered by the department, depending on students interest and availability of expertise.

Elective Papers: PHY/PhD/EP/03 & PHY/PhD/EP/04

Group-A
1. Classical and Quantum Fields
2. Plasma Physics
3. Semiconductor Physics
4. Atomic and Molecular Physics
5. Computer Programming and Numerical Analysis

Group-B
1. Experimental Methods
2. Condensed Matter Physics
3. Nanotechnology and Applications
4. High Energy Particle Physics

Ph.D. Course Work in Physics

Compulsory Papers

Paper: PHY/PhD/CP/01(Research Methodology)

1. Scientific Research:
Research: Definition, Characteristics, types, need of research. Identification of the problem, assessing the status of the problem, formulating the objectives, preparing design (experimental or otherwise), Actual investigation, Determining the mode of attack.

2. Literature survey:
References, Abstraction of a research paper, Possible ways of searching of current literature.

3. Documentation and scientific writing:
Results and Conclusions, Preparation of manuscript for Publication of Research paper, Presenting a paper in scientific seminar. Thesis writing, Structure and Components of Research Report, Types of Report: Research Papers, Thesis, Research Project Reports, Pictures and Graphs, Citation styles, Writing a review of paper, Bibliography.

4. Computer fundamentals: Basic idea of computer fundamentals, Different operating systems, Uses of word processing software- MS Word/Latex/others, Drawing graphs and diagrams using– Origin/Excel/gnuplot/others. Computer usage for collecting/analyzing data– simulations using Fortran/C/Mathematica/Matlab/others. Preparing presentations-Power point for oral and poster presentations

5. Use of internet in research works
Use of internet networks in research activities in searching material, paper downloading and submission in arXives, use of SPIRES database, relevant websites for journals and arXives.

6. Introduction to Patent laws etc.
Patent laws, process of patenting a research finding, Copy right, Cyber laws.

References:

1. Thesis & Assignment Writing–J Anderson, B.H.Dursten & M.Poole, Wiley Eastern, 1977
2. A Hand Book of Methodology of Research – P. Rajammal and P. Devadoss, R. M. M. Vidya Press, 1976.
3. Research Methodology - R. Panneerselvam, PHI, New Delhi 2005
4. How to write and Publish - Robert A. Day and Barbara Gastel (Cambridge Univ.Press)
5. How to Research - Loraine Blaxter, Christina Hughes & Malcum Tight (Viva Books).
6. The Craft of Scientific Writing - Michael Alley, (Springer).
7. A Student’s Guide to Methodology - Peter Clough and Cathy Nutbrown, (Sage Publications).
8. Research methodology techniques and methods - C L Kothari, New Age International publishers.

Paper: PHY/PhD/CP/02 (Review Work and Presentation)

Review work is to be focussed on the essential content of any three papers or review articles in her area of interest. The relevance of research from perspective of the subject, detailed review and scope of the work are to be reviewed.

A presentation will have to be delivered by the research scholar at the end of the semester along with a synopsis/report of her review work.

<u>Elective Papers</u>

Group– A : Paper: PHY/PhD/EP/03

A.1: Classical and Quantum Fields

1.. Classical fields and Euler-Lagrangian equation for fields, Functional derivatives, time derivative, Classical Hamiltonian equation.

2. Relativistic quantum mechanics, Quantization of non-relativistic Schrodinger equation, Dirac γ–matrices and their properties, Charge and current densities , Covariant form of Dirac equation, Dirac equation for a central field-H-atom, Negative energy states.

3. Euler Lagrange equation, Noether's theorem, Quantization of Real and Complex scalar fields,

4. Quantization of Dirac field, Quantization of Electromagnetic field.

References:

1. Classical Theory of Fields – Landau Lifshtiz.
2. *Principles of Quantum Mechanics*- R. Shankar, 2nd ed., 1994
3. *Quantum Mechanics*- L.I.Schiff, 1968
4. *Relativistic Quantum Fields*- J.D. Bjorken & S.D. Drell
5. *Relativistic Quantum Mechanics*- W. Greiner, 2nd Ed.,2001
6. Advanced Quantum Mechanics- J.J. Sakurai, Addison Wesley, 1967
7. Classical Electrodynamics – J.D. Jackson.
8. Quantum Field Theory- L.H. Ryder

A.2 : Plasma Physics

1. Introduction to plasma, concept of temperature, Debye shielding, different plasma parameters. Plasmas as fluids, fluid equations of motion, diffusion and resistivity in plasmas. Plasma oscillations, electron plasma wave, ion wave, Electromagnetic waves both parallel and perpendicular to the magnetic field, Alfvén waves, gas discharge processes, dc and rf discharge, capacitive and inductively coupled plasma systems.

2. Theory and description of different plasma production systems, Dusty plasma, compositions and characteristics, plasma processing. introduction to controlled thermonuclear fusion, magnetic confinement, Tokamak, Spheromak and ITER.

3. Nonlinear phenomena in plasma, plasma sheath, linear and non-linear waves in plasma. instabilities in plasma, streaming instability, drift wave instability and parametric instability.

4. Chaos and time series analysis; Fourier theory, Liapunov exponent, attractors, self-similarity, Hurst exponent and fractal dimension.

References:

1. Introduction to Plasma Physics & Controlled Fusion- F.F.Chen
2. The Physics of Plasmas- T.J.M. Boyd and J.J. Sanderson
3. Methods in nonlinear plasma theory- Ronald C. Davidson (Academic Press)
4. The Physics of Laser Plasma Interactions- W.L.Kruer
5. Industrial Plasma Engineering- J.Reece Roth
6. Introduction to Plasma Theory-Dwight R. Nicholson
7. Instabilities in Space and Laboratory Plasmas - D. B. Melrose
8. Basic Space Plasma Physics- Wolfgang Baumjohann and Rudolf A. Treumann.
9. Fundamentals of Plasma Physics- J. A. Bittencourt

A.3 : Semiconductor Physics

1. **Crystal structure and Band structure:** Study of crystal structure and band structure of silicon, germanium and gallium arsenide semiconductors.

2. **Properties of Semiconductors:** Charge carriers in semiconductors, Hall Effect; Magneto-resistance; Hot carriers; Quantum Hall effect. Thermal effects in semiconductors fundamental, impurity, free carrier and exciton absorption, Radiative and surface recombination, Photoconductivity, Optical processes in quantum wells; Laser action in semiconductors.

3. **Advanced and Novel Electronic Materials:** Amorphous Si, Ge and GaAs, Organic semiconductors, Spintronics materials, Dilute magnetic semiconductors; Semiconductor quantum wells, quantum wires, quantum dots, Semiconductor nano-crystals.

4. **Surfaces and Interfaces:** Surface states, Interface states in semiconductor devices; Characterization of semiconductors and devices by I-V, C-V, G-V and DLTS techniques.

5. **Ultra Large Scale Integrated circuit (ULSI) device technology:** Semiconductor bulk crystal growth, Epitaxy, defects, dislocations and doping in semiconductors, Basic device fabrication processes, Circuit design and fabrication.

References:

1. Semiconductors- R.A. Smith, 2nd edition; Cambridge University Press, London, 1978.
2. Physics of Semiconductors & their Heterostructures- J. Singh, McGraw-Hill,1993.
3. Physics of Amorphous Materials- S.R. Elliott, Longman, London, 1983,
4. Nanophysics and Nanotechnology- . E.L. Wolf, Wiley-VCH Verlag, Weinheim, 2004.
5. Physics of Semiconductor Devices- S.M. Sze, John Wiley, N.Y., 1981,
6. MOS Physics and Technology- E..H. Nicollian an J.R. Brews, John Wiley, 1982,
7. Semiconductor Devices-Physics and Technology- S.M. Sze, John Wiley, 1985

A.4 : Atomic and Molecular Physics

1. **One and Many Electron Atoms:** Electronic states of one and many electrons atoms, L-S and J-J coupling schemes, Hund's rule, Briet scheme, Many electron wave function, Variation method, Hartree-Fock self consistent method.

2. **Molecular approximations and states:** Born-Oppenheimer approximation, Electron shells of di-atomic molecules, Spectroscopic notation, Shape of molecular orbitals, LCAO method and its applications to molecules or ions.

3. **Molecular Rotation and Vibration and Electronic Spectra:** Rotational spectra-Rigid and non-rigid rotators. Vibrational spectra- Harmonic and anharmonic oscillator, Diatomic vibrating-rotator. Electronic spectra- Vibrational course structure and Rotational fine structure, Frank-Condon principle.

4. **Molecular Symmetry:** Symmetry point groups, Symmetry elements and operations, Vibrational modes of linear and non-linear tri-atomic molecules,.

5. **Ab initio Treatments**: Hartree-Fock method, Moller Plasset Perturbation Theory, Configuration Interaction method etc.

6. **Atomic& Molecular Packages:** Uses of free/licensed softwares for atomic and molecular systems to study their various spectroscopic properties.

References:

1. Physics of Atoms and Molecules- B.H. Bransden and C.J. Joachin (John Willey)
2. Atomic spectra- H. E. White (East-West Press)
3. Quantum Chemistry - I. N. Levine (Pearson Pub.)
4. Fundamentals of molecular spectroscopy – C.N. Banwell
5. Molecular spectroscopy – C. Barrow
6. The elements of Physical Chemistry - Atkins (Oxford)
7. Molecular spectra and molecular structure – G. Herzberg (Vol.I, II & III)

A.5 : Computer Programming and Numerical Analysis

1. **Basic Numerical Methods**: Numerical integration (Trapezoidal and Simpson's method), Numerical differentiation; Diagonalization and inverse of symmetric and non-symmetric matrices, Eigenvalues and eigenvectors
2. **Root finding**: Bisection and Newton-Raphson method; Interpolation techniques; Solution of ordinary differential equations (Euler and Runge-Kutta methods).
3. **Statistics analysis of data:** Data acquisition system, error propagation, curve fitting, Least square method, Sampling and parameter estimation, the maximum likelihood method.

4. **Simulation and Monte Carlo Method**: Simulation of Random variables, discrete and continuous. Calculation of integrals. Monte Carlo evaluation of pi. Simulation of simple processes: coin tossing or dice throwing game. Examples and applications.

References:

1. Numerical methods for Scientific and Engineering Computation - M. K. Jain, S. R. K. Iyengar and R.K.Jain. (Wiley Eastern Limited)
2. Fortran 77 and Numerical Methods: C.Xavier (New Age International Publishers)
3. Techniques for Nuclear and Particle Physics Experiments, How to approach: W.R.Leo (Narosa Publishing House)
4. Numerical Recipes: W.Press et.al., (Cambridge University Press)
5. Data reduction and error analysis for the Physical Sciences, 3e, Philip R Bevington & D. Keith Robinson . McGraw Hill (2003)

Group– B : Paper: PHY/PhD/EP/04

B.1: Experimental Methods

1. Preparation of Materials: Preparation of various materials using different technologies,

2. **Thin Film Technology:** Synthesis of thin films for research and technological applications: various methods.

3**. Vacuum Technology:** Production and Measurement of Rough to Ultra High Vacuum; Designof vacuum systems; Leak detection methods, Vacuum Materials.

4. **Ion Beam Techniques:** Synthesis, Modification and Processing of novel Materials; Ion beamanalysis- SIMS, RBS, Channeling, ERDA.

5. **Modern Analytical Tools:** XRD, XPS, TEM, SEM, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, PL, STM, AFM, absorption, device characterization etc.

References:

1. Vacuum Technology - A. Roth, North Holland, Amsterdam, 1982.
2. Thin film phenomena- K.L. Chopra, Mc-Graw Hill, New York, 1969.
3. Ion Implantation- G. Dearnaley, J. H. Freeman, R. S. Nelson. and J. Stephen, North-Holland, Amsterdam, 1973.
4. Fundamentals of surface and Thin Films Analysis- L. C. Feldman and J.W. Mayer, North-Holland, Amsterdam, 1986.
5. Great Experiments in Physics - M. H. Shamos, Dover Publication, 1987

B.2 : Condensed Matter Physics

1. Electronic and Optical Properties:

Single electron model, density of states, Fermi surface and quasi-particles;

Thermodynamic properties: Review of thermodynamics, statistical mechanics of non-interacting electrons, Sommerfeld expansion, specific heat, magnetic susceptibility;
Transport properties: Drude Model, electrical conductivity, thermal conductivity thermo-electric phenomena. Band theory.
Electrons in periodic potentials, Bloch's theorem, Kronig-Penney model, Brillouin zones, nearly free and tightly bound electrons, Fermi surfaces, band theory, effective mass, Wannier functions and tight binding, survey of the periodic table;
Optical properties of metals, optical properties of semiconductors, direct and indirect band gaps, polarization, Clausius-Mosotti relation, polarons, point defects and color centres, anomalous skin effect, plasmons, Brillouin and Raman scattering;

2. Magnetism:
Introduction, fundamental definitions, different types of magnetic materials, Weiss theory of ferromagnetism, domain theory of ferromagnetism, hysteresis, Hard and Soft magnetic materials, Ferri- and anti-ferromagnetism, Spin waves, Magnetic resonance Phenomenon.

3. Superfluidity and Superconductivity:
Superfluidity of Helium, BEC, Landau argument, two-fluid model, BEC in atomic gases, superconductivity, Phenomenological description of superconductivity, critical temperature, Meissner effect, magnetic properties, critical field, London equation, microscopic theory, qualitative features, Ginzburg–Landau theory; magnetic properties of Type – II superconductors; Josephson effect. Hg-Te superconductors.

4. Soft Condensed Matter Physics:
Interactions in soft matter, entropic interactions, fluctuation induced interactions, hard sphere statistical mechanics and crystallization;

Self-assembly of amphiphiles, phases, theoretical approaches; Colloids, self-assembly, the freezing transition;
Polymers, polymer structure, self-avoidance, Edwards model, osmotic pressure, Flory-Huggins theory, screening, semi-flexibility, persistence length;

Liquid crystals, nematic, cholesteric and smectic, order parameters, Frank free energy, Landau-de Gennes model defects, defect phases;

Survey of hydrodynamics, hydrodynamic approaches to soft matter physics, dynamical properties of polymers, membranes, colloids; Soft matter away from equilibrium, shear-induced phases;

References:
1. Solid State Physics- N.W. Ashcroft and N.D. Mermin (Brooks Cole).
2. Theoretical Solid State Physics - W. Jones and N.H. March
3. Solid State Physics- J. Richard Christman, Solid State Physics (John Wiley).
4. Introduction to Solid State Physics- C. Kittel (Wiley).
5. Principles of Condensed Matter Physics -P.M. Chaikin & T.C. Lubensky (Cambridge Univ. Press).

B.3: Nanoscience and Nanotechnology

1. Background to Nanotechnology

Scientific revolution- Atomic structures-Molecular and atomic size-Bohr radius – Emergence of Nanotechnology – Challenges in Nanotechnology - Carbon age– New form of carbon (from Graphene sheet to CNT).

2. Nucleation

Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties.

3. Types of Nanostructures

Definition of a Nano system - Types of Nanocrystals- One Dimensional (1D)-Two Dimensional (2D) -Three Dimensional (3D) nanostructured materials - Quantum dots - Quantum wire Core/Shell structures.

4. Nanomaterials and properties

Carbon Nanotubes (CNT) - Metals (Au, Ag) - Metal oxides (TiO_2, Cu_2O, ZnO) - Semiconductors (Si, Ge, CdS, ZnSe, PbS) - Ceramics and Composites - Dilute magnetic semiconductor- Size dependent properties -Mechanical, Physical and Chemical properties.

5. Applications of Nanomaterials

Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display - Biological applications - Biochemical sensor - Membrane based water purification.

References:

1. Nanotechnology: Basic science and Emerging technologies-. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. The chemistry of nanomaterials: Synthesis, properties and applications- C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), Wiley VCH Verlag Gmbh & Co, Weinheim, 2004.
3. Nanoscale Materials Science- Kenneth J. Klabunde (Eds), John Wiley & Sons, InC, 2001.
4. Nanofabrication towards biomedical applications- C.S.S.R.Kumar, J.Hormes, C.Leuschner, Wiley, 2004.
5. Nano Electronics and Information Technology- W. Rainer, Wiley, 2003.
6. Nano systems- K.E.Drexler Wiley, 1992.
7. Naostructures and Nanomaterials: Synthesis, properties and applications- G.Cao, ImpericalCollege Press, 2004.

B.4: High Energy Particle Physics

1.Introduction to Gauge theory of fundamental interactions, Covariant Perturbation theory, Feynman diagrams in momentum space and its applications in QED and QCD.Lie groups: SU(2), SU(3) and SU(5) and their applications: Higgs Mechanism and Goldstone theorem and its application in gauge theories.

2. Feynman Rules for spin 0 and spin ½ particles and their applications, Parton model, Deep Inelastic Scattering (DIS), QCD-evolution equations. Standard Model of Electroweak Interaction

3.Introduction to Supersymmetry, Minimal Supersymmetric Standard Model (MSSM), Dark Matter, Neutrino Physics, Introduction to GUT models

4.Introduction to Large Hadron Collider (LHC), Detectors: ATLAS, CMS, ALICE and LHCb.

5.Introduction to Software packages for learning simulation techniques: CalcHEP, PYTHIA, SUSYHIT etc.

References:

1. An Introductory Course of Particle Physics- P. B. Pal
2. Quarks and Leptons:An Introductory Course in Modern Particle Physics- F. Halzen and A.D. Martin
3.Gauge Theory of elementary particle physics- T. P. Cheng and L.F. Li
4.Introduction to Elementary Particles- D. Griffiths
5. Introduction to High Energy Physics- D. H. Perkins
6. Theory and Phenomenology of Sparticles- M. Drees, R. M. Godbole and P. Roy
7. Massive Neutrinos in Physics and Astrophysics- R. N. Mohapatra and P. B. Pal

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