UNIVERSITY OF NORTH BENGAL

Accredited by NAAC with Grade "A"

Enlightenment to Perfection

Syllabus for Ph.D. Course-work and M.Phil Programme in Physics

(Framed in compliance with the UGC Regulations, 2016)

(To be implemented from Session 2018-2019)

Department of Physics
University of North Bengal

Ph. D. Course Structure: 1 Semester
(8 credits :200 marks)

Course Phy-101: Computer Applications [2 Credits, 50 Marks (CE-25 + ESE – 25), L-2 Hrs/week Total L-64]

Course Phy-102: Quantitative Methods [2 Credits, 50 Marks (CE-25 + ESE – 25), L-2 Hrs/week Total L-64]

Course Phy-103 & Phy-104: Advanced Level Subject Specific Courses: Any two courses to be chosen out of the offered courses.

(For each module 2 Credits, 50 Marks (CE-25 + ESE – 25), L-2 Hrs/week Total L-64)

M.Phil Course Structure: 4 Semesters
(32 credits : 800 Marks)

Semester I
(8 credits, 200 marks and common with Ph.D. Course work)

Course Phy-101: Computer Applications 2 Credits 50 Marks (CE-25 + ESE – 25) L-2 Hrs/week Total L-64

Course Phy-102: Quantitative Methods 2 Credits 50 Marks (CE-25 + ESE – 25) L-2 Hrs/week Total L-64

Course Phy-103 & Phy-104: Advanced Level Subject Specific Courses: Any two courses to be chosen out of the offered courses.

(For each module 2 Credits 50 Marks (CE-25 + ESE – 25) L-2 Hrs/week Total L-64)

[For each module 2 Credits 50 Marks (CE-25 + ESE – 25) L-2 Hrs/week Total L-64]

Semester II
(8 credits, 200 marks)

Course Phy-201 to Phy-204: Advanced Level Subject Specific Courses: Any four courses to be chosen out of the offered courses which will be different from the advanced level courses taken in Semester I.

[For each module 2 Credits 50 Marks (CE-25 + ESE – 25) L-2 Hrs/week Total L-64]

Semester III
(8 credits, 200 marks)

Course Phy-301 : Review of published papers on a topic (4 credits, 100 Marks, T-2 Hrs/week, Total T-64)

(Write up- 50, Presentation-25, Open Viva-25)

Course Phy-302: Review of published thesis on a topic/Project Work (4 credits, 100 Marks, T-2 Hrs/week Total T-64) (Write up-50, Presentation-25, Open Viva-25)

Semester IV
(8 credits, 200 marks)

Course Phy-400: Dissertation (8 credits, 200 Marks, T-2 Hrs/week Total T-64) (Thesis-150, Presentation cum Open Viva-50)

**** CE – continuous evaluation, ESE – End Semester Examination, L – Lecture, T- Tutorial**

Syllabus

Course Phy-101: Computer Applications

Operating System – Linux, Graphics packages – Excel and Origin, Numerical techniques, Simulations and Graphics in Matlab.

Course Phy-102: Quantitative Methods

Probability and Statistics; Population and sample; Mean, median, mode and moments of a distribution; Major statistical distributions and their characteristics; Error Analysis and Error Propagation; Least-Squares Fit – Straight line, Polynomial, Arbitrary Function; Testing the Goodness of Fit.

Advanced Level Subject Specific Courses for Courses Phy-103, Phy-104, Phy-201, Phy-202, Phy-203 and Phy-204:

Each course is of 2 credits, 50 Marks.

In each semester the department will offer courses depending on the availability of faculty.

ALC 01 (Standard Model of Particle Physics)

- Introductory Quantum Field Theory
- Abelian and Non-abelian Gauge Theories
- Yang-Mills Theory
- Quantum Chromodynamics
- Spontaneous Symmetry Breaking
- The Electroweak model of Leptons
- Electroweak Interaction of Hadrons
- CP symmetry and its violation
- Neutrino Physics

ALC 02 (High-energy Heavy Ion Interaction)

- Introduction to high-energy heavy-ion interaction
- Relativistic kinematics, and general features of high-energy nucleus-nucleus collisions
- MIT Bag model of hadrons
- Statistical mechanics and thermodynamics of hadronic and/or partonic matter at high-temperature and/or at high-density
- Relativistic hydrodynamics of hadronic and/or partonic matter – Fermi, Landau and Bjorken's model
- Quark-gluon plasma to hadronic matter phase transition and QCD phase diagram
- Signatures of QGP – quantitative discussion for a few
- Experimental status

ALC 03 (General Theory of Relativity)

- Elements of Differential geometry, vectors, tenors and one-forms, abstract index notation.
- Curvature: derivative operators and parallel transport, curvature tensor, Ricci tensor, curvature scalar, Bianchi identity, geodesics.
- Principle of Equivalence, energy momentum tensor, Einstein field equation, linearised gravity, gravitational radiation.
- Symmetric space times, Killing vectors, Schwarzschild solution, Kruskal extension classical tests of GR, Schwarzschild interior solution. Kerr and Kerr Newman solutions (without derivation).
- Black holes, general properties of black holes, overview of black hole thermodynamics.

ALC 04 (Astrophysics)

Magnitudes, Absolute and relative magnitudes, distance modulus, Hertzsprung – Russel diagram, the Sun, its structure and different properties, derivation of Hydro-dynamical equilibrium (General Relativistic), Newtonian star, stellar structure, stellar evolution, white Dwarf, Chandrasekhar mass limit, Neutron star, Black holes, Pulsar, X-ray sources, Techniques of Astrophysical DATA Analysis.

ALC 05 (Cosmology)

Einstein's field equation, solutions of the Einstein's field equation for barotropic fluids, Einstein's Static Universe, Hubbles Law, Einstein- de Sitter universe, Friedmann model of the Universe, Age of the universe, Particle Horizon, Event Horizon, Bigbang theory, Problems of Big bang theory, Inflation, different parameters in cosmological model building, deceleration parameter, Density parameter, Accelerating Universe, Dark matter, Dark Energy, Modified Einstein Field equation.

ALC 06 (Liquid Crystal Theoretical)

- Types of Liquid Crystals
- Identification of Liquid crystalline phases
- Molecular theories of nematic liquid crystals
- Molecular theories of Smectic A liquid crystals
- Landau-de-Gennes theory of phase transition in liquid crystals
- X-ray diffraction studies of Liquid Crystals
- Liquid crystal displays

ALC 07 (Experimental Techniques in Condensed Matter Physics)

X-ray diffraction Technique, TEM, SEM, AFM Techniques.

ALC 08 (Experimental Techniques in Nuclear and Particle Physics)

- Kinematics of interaction: Laboratory system – Centre of mass system; Rapidity; Invariant mass; Invariant Cross-section; Feynman variables
- Particle Acceleration: Large accelerators world-wide; Acceleration and focussing; Dipoles and Quadrupoles
- Particle Detection: Hadron spectrometer – identification through (i) dE/dx measurement, (ii) time of flight measurement, (iii) Cherenkov radiation; Lepton pair spectrometer; Photon spectrometer; Neutrino detection; Neutron detection; A few examples of Large Hybrid Detectors.

ALC 09 (Experimental Techniques in Microwave)

- Formulation and Application of Scattering Matrix
- Measurement of S-parameter
- Measurement of microwave power and frequency
- Time Domain reflectrometry
- Frequency Domain reflectrometry
- Measurement of dielectric constant of materials in microwave frequency
- Smith Chart and its use for the measurement of unknown impedance.

ALC 10 (Liquid Crystal Experimental)

- Measurement of basic physical properties of Liquid Crystal:
  (a) Optical anisotropy; (b) Dielectric anisotropy; (e) magnetic anisotropy
  (c) Elastic Constants; (d) Rotational Viscosity.
- Structural investigation of different liquid crystalline phases.
  (a) x-ray diffraction
  (b) Nuclear Magnetic Resonance
- Experimental methods for investigating relaxation phenomena in Liquid crystal
  (a) Time domain dielectric spectroscopy
  (b) Frequency domain dielectric spectroscopy
- Study of electro-optical properties of Liquid Crystals

ALC 11 (Simulation Techniques in High-Energy Physics)

- Object oriented programming in C++/FORTRAN
- LINUX/UBUNTU – scientific
- Data analysis framework – ROOT
- Introduction to detector simulation – GEANT
- Familiarity with event generators like: CORSIKA, EPOS, QGSJet, Sybill, Fluka, PYTHIA, UrQMD, AMPT, HIGING, Therminator – (any four)
- Techniques of data analysis and theory of errors

ALC 12 (Many-body theory in Condensed Matter Physics)

- First and second quantization
- Electron gas
- Mean field theory
- Linear response theory
- Green's function
- Equation of motion theory
- Superconductivity

ALC 13 (Low dimensional quantum systems)

- Heterostructures
- Quantum wells and low dimensional systems
- Tunneling transport.
- Electric and Magnetic field effects
- Scattering rates
- Spin-Orbit interactions in semiconductor
- Graphene and other Dirac materials

Course Phy-301:

Review of published papers on a topic

Course Phy-302:

Review of published thesis on a topic/Project Work

Course Phy-400:

Dissertation