Syllabus for Coursework in

Ph.D. (Physics) Programme

NAGALAND UNIVERSITY

HQs: LUMAMI - 798627

Department of Physics

School of Sciences

DEPARTMENT OF PHYSICS
COURSE WORK FOR PRE-PH.D. PROGRAMME

Total Marks – 300

Total Credit – 15 credits

Total Duration: One semester

Course Number : PHY–801, PHY–802, PHY–803

Course No.	Name of the Course	Total Marks	Total Credits
PHY–801	Research Methodology	100	5
PHY–802	Elective Paper	100	5
PHY–803	Literature review, Report writing and Seminar	100	5

Elective Papers for PHY–802:

A. Advanced Quantum Mechanics

B. Experimental Techniques (Theory)

C. Advanced Condensed Matter Physics

Distribution of marks for PHY–803**:**

- Review of Literature, Report Writing – 60 marks
- Seminar – 30 marks (Evaluated by the Department)

Assessment of the course work will be made on grading system. The grading pattern will be as follows:

Marks	Grade	Remark
81-90	O	Excellent
71-80	A	Very Good
61-70	B	Good
51-60	C	Fair
40-50	D	Poor

For qualifying the course one has to secure minimum C – grade.

Course Title: Research Methodology
Course Number: PHY–801
Total Marks: 100
Total Credits: 5

UNIT-I: Definition of problem and presentation of results

1. Overview of research methods involved – literature survey: journals, books, making hypothesis and model building, testing a hypothesis for acceptance or rejection
2. Introduction to presentation – poster, journals article, seminar

UNIT-II: Data acquisition/analysis

1. Automation and computer interface – introduction to basic concepts of computer interface
   (a) DAQ cards (b) RS232, GPIB, TCP/IP protocols for instruments control.
   Introduction to Lab View
2. Data Analysis – Plotting, systematic errors, plotting of error bars, curve fitting etc.
3. Design Elements – Basics of machine drawing, visit to workshop, practice etc.

UNIT-III: Computational tools

1. Introduction and scope of various programming techniques like FORTRAN, C, Mathematica, Matlab – packages like LaTeX, Word, Power Point, Excel
2. Application of above for real physics problems. (for extra assignments)

UNIT-IV: Exposure to advanced research techniques

Laboratory experience on systems like Vacuum techniques, XRD, Thin film deposition system, Electron Microscopy, AFM, Raman, NMR, Fluorescence spectrometer etc.

UNIT-V: Computer Simulations

Computer simulation of Physics problems – molecular dynamics, Monte Carlo Techniques, Density functional theory etc.

Reference Books:

1. R. Rajaraman, Computer Programming in Fortran 90 and 95, Prentice Hall, (India), 1997.
2. R. Rajaraman, Computer Programming in Fortran 77, Prentice Hall (India), 1997.
3. T. Richard McCalla, Introduction to Numerical methods and FORTRAN Programming, John Wiley & Sons, Inc. 1967.

4. Gopal Lal Jain; *Research Methodology, Methods, Tools and Techniques*; 2nd Ed., 2003, Mangal Deep Publications, Jaipur.
5. Michael Quinn Patton, *Qualitative Research & Evaluation Methods*, 3rd Ed., 2002, Sage Publications, Inc.
6. S.C. Sinha and A.K. Dhiman, *Research Methodology*, 2002, Ess Ess Publications, New Delhi.
7. S.L. Jat, N.P. Agarwal, M.S. Poonia, *Research Methodology*, 2007, Indus Valley Publications, Jaipur.

Course Title: Advanced Quantum Mechanics (Elective)
Course Number: PHY–802 (A)
Total Marks: 100
Total Credits: 5

UNIT-I Perturbation theory: Time-independent Perturbation theory, Non-degenerate and degenerate cases (upto second order). Applications: Zeeman effect, Stark effect, anharmonic oscillator.

UNIT-II Time-dependent Perturbation theory: Transition amplitude 1st and 2nd order, selection rules, constant perturbation (1st order). Fermi's golden rule, Harmonic perturbation, Interaction of atom with electromagnetic radiation, dipole approx. Einstein coefficient for spontaneous emission.

UNIT-III Variational method: Basic principles and applications to particle in box, Harmonic oscillator, hydrogen atom, helium atom. (Qualitative approach)

UNIT-IV WKB approximation: Qualitative development and condition for validity of this approx., Bohr's quantization condition, applications to tunnelling such as a-particle, field emission. Einstein's coefficients.

UNIT-V Relativistic Quantum Mechanics: Klein-Gordon equation, Non-relativistic limit, Dirac equation, properties of Dirac Matrices, positive and negative energy states. Spin of the Dirac particle, Significance of negative energy states, Free Dirac particle in an external electro-magnetic field, relativistic electron in a central potential.

Reference Books:

1. Quantum Mechanics – Leonard I. Schiff, 3rd Edition, Tata McGraw-Hill Education Private Limited, New Delhi. (2010).
2. Quantum Mechanics – Eugene Merzbacher, 3rd Edition, John Wiley & Sons, New York (1998).
3. Practical Quantum Mechanics – S. Flugge, 1st Edition, Springer-Verlag New York (1998)
4. A text book of Quantum Mechanics – Mathews and Venkatesan 2nd Edition, McGraw-Hill Education Private Limited, New Delhi (2010).
5. Introduction to Quantum mechanics – David J. Griffiths, Prentice Hall, Inc. USA (1995).
6. Quantum mechanics – A.Ghatak and S.Lokanathan, McMillan publishers India Limited, New Delhi (2010)

Course Title: Experimental Techniques (Theory) (Elective)
Course Number: PHY–802 (B)
Total Marks: 100
Total Credits: 5

Energy and time scales for physical phenomena occurring in Condensed Matter and appropriate experimental probes:

UNIT-I Infrared Spectroscopy: Rotational and vibrational spectra of Diatomic molecule, Harmonic and Anharmonic oscillator, Rotational constants from Infrared and Raman vibration-rotation spectra. Fourier transform of IR spectroscopy – Theory, Experimental setup and applications.

UNIT-II Electron Spin Resonance: Basic Principle and theory, ESR spectrometer, experimental methods, thermal equilibrium and Relaxation methods, characteristics of g and A values, Unpaired electron, fine structure and Hyperfine structure.

UNIT-III Nuclear magnetic resonance: Basic Principle and theory, Nuclear spin and Magnetic moment, Relaxation mechanism, spin-lattice and spin-spin relaxation, Pulse method, Bloch's equations and solution, Experimental methods, CW NMR Spectrometer.

UNIT-IV Nuclear quadrupole resonance: Fundamental requirements of NQR spectroscopy, General principles, Integral spins and Half Integral Spin., experimental detection of NQR frequencies, block diagram of NQR spectrometer, Experimental methods of SR oscillator, CW oscillator, pulse methods.

UNIT-V Mössbauer spectroscopy: Mössbauer Effect, Recoil less Emission and Absorption, Mössbauer spectrometer, Experimental Methods, Chemical shift, Magnetic Hyperfine interactions.

Basics of Auger spectroscopy, Terahertz, Circular Dichroism spectroscopy, Inelastic neutron scattering, Neutron spin echo, Scanning tunneling spectroscopy, X-ray photoelectron spectroscopy.

Reference Books:

C. N. Banwell: Fundamentals of Molecular Spectroscopy (McGraw-Hill, 1983).
S. W. Lovesey: Theory of Neutron Scattering from Condensed Matter (Oxford, 1984).
L. C. Feldman, J. W. Mayer, S. T. Picraux: Materials Analysis by Ion Channeling (Academic Press, 1982).

Course Title: Advanced Condensed Matter Physics (Elective)
Course Number: PHY–802 (C)
Total Marks: 100
Total Credits: 5

Magnetism and properties of magnetic materials

UNIT-I Diamagnetism and paramagnetism: Review of elementary and quantum theories of diamagnetism and paramagnetism. Effect of crystalline field, Quenching of orbital angular momentum. Relaxation and resonance phenomena, NMR,

UNIT-II Ferromagnetiam: Molecular field theory, Heisenberg model, Mean field solution, The series expansion method, The Bethe-Peierls-Weiss method, Holstein-Primakoff transformation, Magnons; Itinerant ferromagnetism, Stoner model, Wohlfarth's modification; Crystalline anisotropy magnetoelastic effects, Magnetisation of ferromagnetic materials.

UNIT-III Antiferromagnetism: Molecular field theory, Superexchange. Double-exchange. Series- expansion method, Bethe-Peierls-weiss method, Spin waves, Crystalline anisotropy, Domains in antiferromagnetic materials.

UNIT-IV Ferrimagnetism: Molecular field theory, Spinels, Garnets, Quantum mechanical theories. Ferromagnetic, antiferromagnetic and ferrimagnetic resonance, Mossbauer effect. The s-d Zener model, Kondo effect, RKKY interaction, Spin glass.

UNIT-V Strongly correlated electron systems: Hubbard model, Different solutions of the Hubbard model, Mott transition. Localized states in disordered lattice, Anderson model, Metal-insulator transition.

References:

1.	Introduction to Solid State Physics	C. Kittel
2.	Solid State Physics	J. S. Blakemore
3.	Principles of Solid State Physics	R. A. Levy
4.	Principles of the Theory of Solids	J. Ziman
5.	Physical Principles of Magnetism	A. H. Morrish
6.	Physics of Magnetism	S. Chikazumi
7.	Quantum Theory of Magnetism	R. M. White
8.	Relaxation Phenomena in condensed matter	S. Dattagupta