School of Physics (Autonomous), Sambalpur University
M.Phil. Physics Course Structure

<u>I Semester</u>

Course No	Course Title	Credit
PHY – 611	Advanced Quantum Mechanics and Applications (Compulsory)	4 CH
PHY – 612	Materials Physics and Devices (Elective)	4 CH
PHY – 613	Research Methodology (Quantitative Analysis and Application)	4 CH
PHY – 614	Advanced Application of Computer in Physics (Practical)	4 CH
PHY – 615	Review of Research Papers	4 CH
Total of I Semester		**20 CH**

<u>II Semester</u>

Course No	Course Title	Credit
PHY – 621	Seminar (At least Two)	2 CH
PHY – 622	Dissertation	18 CH (Interim 8 CH + Final 10 CH)
Total of II Semester		**22 CH**

COURSE: PHY – 611 **4 CH**

ADVANCED QUANTUM MECHANICS AND APPLICATIONS (COMPULSORY)

Unit - I

Klein-Gordan Equation: Negative energy, Probability density and energy levels in H-atom, Dirac equation, Free particle Dirac Equation, Covariant Formulation, Lorentz Covariance of Dirac equation, Bilinear co-variants and transformation properties, algebra of Dirac γ-matrices, plane wave solutions, negative energy states and Dirac hole theory. Spin of Dirac electron.

Unit - II

Dirac Equation in an electromagnetic field and non-relativistic correspondence, Zitterbewegung, Orthonormality and Completeness relation for spinors, evaluation of spinor summation, H-atom in Dirac theory.

Path integral Quantisation: Propagator in Path integral approach, free particle propagator, equivalence of path integral method to Schrödinger equation, propagator for Harmonic Oscillator.

Unit – III

Field Theory: Lagrangian formulation of particle mechanics, Real scalar field, Variational Principal and Noether's Theorem, Complex scalar field, Dirac field and electromagnetic field, Quantisation of real and complex scalar field.

Unit – IV

Modern Application of Non-Relativistic Quantum Mechanics:

The infinite well, In-plane dispersion, Density of States, Finite Well with constant mass, Extension to multiple well systems, asymmetric single quantum well, Addition of electric field, infinite superlattice, single barrier, double barrier, extension to include electric field. Quantum wire and dots: infinitely deep rectangular wires, circular cross-section wire, quantum boxes, spherical quantum dots, density of states.

Texts and References:

1. J.D. Bjorken and D.S. Drell: Relativistic Quantum Mechanics (Vol. - I) (Vol. - II)
2. L.H. Ryder: Quantum Field Theory
3. B.K. Agarwal : Quantum Mechanics and Field Theory
4. L. Schiff: - Quantum Mechanics
5. R.P. Feynman and A.R. Hibbs: Quantum Mechanics and Path integral
6. C. Itzykson and J.B. Zuber: Quantum Field Theory
7. Paul Harrison: Quantum Wells, Wires and Dots (John Wiley and Sons Ltd)

COURSE: PHY – 612 **4 CH**

MATERIALS PHYSICS AND DEVICES (ELECTIVE)

Unit I

Superconducting Materials: BCS theory, Flux quantization, Josephson effect, High T_C superconductor, other superconducting materials, Applications.

Magnetic materials: Different Type of Magnetic Materials and their properties, Weiss Molecular Field Theory of Ferromagnetism, Antiferromagnetism, Ferrimagnetism, Applications.

Dielectric materials: Polarization mechanism, Dielectric constant, temperature dependence of dielectric constant, behavior of dielectric in AC field, Dielectric loss, Dielectric breakdown, ferroelectric, piezoelectric, pyroelectric materials, Applications.

Unit II

Ceramic Materials:

Materials Properties and Requirements, Classification of Engineering Materials: Metals, polymers, ceramics, composites, nanocrystalline, nonlinear, biomaterials.

Definition of Ceramics, Ceramic Microstructure, Traditional Versus Advanced Ceramics, General Characteristics of Ceramics, Applications. Ceramic Structure, Binary Ionic Compound, Composite Crystal Structure, Structure of Covalent Ceramics, Lattice Parameters and Density.

Modern Materials:

Polymers, Composite Materials, Meta materials and smart materials, memristic and super-insulating materials and their applications.

Optical materials:

Scattering, refraction, theory of refraction and absorption, Reflection and transmission, Atomic theory of optical properties, Quantum theory of optical properties, Fiber optics, holography, Magneto optic and electro optic materials.

Unit III

Synthesis and Characterization: High Temperature Ceramic Methods, Microwave Synthesis, Combustion Synthesis, High Pressure Method, Chemical Vapour Deposition (CVD), Preparing Single Crystals, Intercalation, Choosing Method. Sintering and Grain Growth: Solid-State Sintering, Liquid-Phase Sintering, Hot Pressing and Hot Isostatic Pressing.

X-ray Diffraction, Powder Diffraction, Single Crystal X-ray Diffraction, Neutron Diffraction, Electron Microscopy, X-ray Absorption Spectroscopy, Solid State Nuclear Magnetic Resonance Spectroscopy (MAS NMR), Thermal Analysis, Scanning Tunneling Microscopy (STM) and Atomic Force Microscopy (AFM), Mossbauer Spectroscopy, Temperature Programmed Reduction (TPR).

Unit IV

Semiconductor devices: HBT, MODFET, IMPATT, THz devices, micro and mm wave devices; Optical devices: Quantum well Lasers, long wavelength detectors, integrated optical devices, Magnetic and superconducting devices: SQUIDS, Spintronic devices, Ferroelctric Memory Devices, Pyroelectric Devices, Piezoelectric Devices, Display Devices, Shape Memory Alloy, Electro-optic Devices**.**

Texts and References:

1. Solid State Physics: A.J. Dekker
2. Introduction to Solid State Physics: C. Kittel
3. Solid State Chemistry: An Introduction: Lesely E. Smart and Elaine A. Moore (Taylor & Francis)
4. Materials Science: M.S. Vijaya and G. Rangarajan (Tata McGraw-Hill)
5. Materials Science: V.Rajendran and A. Marikani (Tata McGraw-Hill)
6. Fundamentals of Ceramics: M.W. Barsoum (Taylor & Francis)
7. Electroceramics: Materials Properties Application: A.J. Moulson & J.M. Herbert (Wiley)
8. Electronic Properties of Materials: Rolf E. Hummel
9. Physics of Semiconductor Devices: S.M. Sze
10. Elements of X-ray diffraction: B.D. Cullity
11. Ferroelectric Devices: Kenji Uchino

COURSE: PHY – 613 **4 CH**

RESEARCH METHODOLOGY (QUANTITATIVE ANALYSIS AND APPLICATION)

Unit - I

Application of statistical concept / procedures, data, diagrammatic, representation of data, probability, Measure of central tendency, Measures of dispersion, Skewness and kurtosis. Normal distribution: Simple correlation, multiple correlation, regression analysis, Sampling simple random sampling, stratified random sampling, Systematic sampling.

Unit - II

Testing of Hypothesis tests. χ (Chi-square), t and F-tests; Analysis of Variance; Covariance; Principal component analysis, Experimental design: Completely randomized block design, Randomized block design, Latin square design. One-way analysis of variance, two way analysis of variance, Follow up tests; Non parametric procedure; Writing of research reports.

Unit - III

Windows and/or Linux operating system; Programming fundamentals; Basics of a high level language-C; Editing compilation and running a program-storing data: Elementary numerical methods (as per requirement of the subject): Plotting graph; Preparing paper/report using Latex.

Unit - IV

Learning software packages specific to the subject. Depending on the knowledge level of the student on different packages he/she will be assigned few packages for study. Questions will be asked on all the packages assigned.

Texts and References:

1) D.K. Bhattacharyya, Research Methodology, Excel Books, New Delhi, II Edition, 2006.
2) C.R. Kothari, Research Methodology.
3) S.C. Gupta, and V.K. Kapoor, Fundamental of Mathematical Statistics, S. Chand, New Delhi.
4) E. Balguruswamy, Programming in C.
5) P.K. Sinha and Priti Sinha, Computer Fundamentals, BPB Publication.
6) P. Richard, Linux: The complete Reference, Mc GrawHill.
7) J.B. Scarborough, Numerical Mathematical Analysis, Oxford and I.B.H.

COURSE: PHY – 614 **4 CH**

ADVANCED APPLICATION OF COMPUTER IN PHYSICS (PRACTICAL)

The student should perform the following experience.

1. Learning to plot graph (using xmgr, gnuplot or similar software).
2. Preparing a manuscript for journal submission using Latex or similar software involving all aspects of a paper.
3. Determination of Eigen values and Eigen vectors of a matrix by numerical methods.
4. Solution of Schrödinger equation for some common potential.
5. Solution of Lagrangian Equation.
6. Solution of Electromagnetic wave Equation.
7. Numerical Solution of cubic Equation.
8. Evaluation of functions: Bessel/Hyper geometric.
9. Random number generation.
10. Solution of Boltzman transport equation.
11. Fast Fourier Transform and Wavelet transform.
12. Minimization or maximization of function using First derivatives (one dimension).

COURSE: PHY – 615 **4 CH**

REVIEW OF RESEARCH PAPERS

Each candidate will be assigned a topic of research and he/she will make a comprehensive review of works done in the area of research. He/she will submit a review report and present a seminar on his/her review work. The review report will be evaluated by the supervisor and the seminar by at least two faculty members.