Department of Physics
Bir Tikendrajit University
Syllabus for M.A. Physics

Course Code	Course Title	Marks
FIRST YEAR		
PHY-411	Mathematical Methods in Physics	100
PHY-412	Classical Mechanics	100
PHY-413	Quantum Mechanics I	100
PHY-414	Electronic Devices	100
PHY-415P	Lab 1 (Electronics & General)	200
PHY-416	Quantum Mechanics II	100
PHY-417	Statistical Physics	100
PHY-418	Electrodynamics & Plasma Physics	100
PHY419	Condensed Matter Physics	100
PHY420P	Lab 2 (Electronics & CMP)	200
	Total Marks	**1200**

*For each theory paper, 25 marks out of 100 marks is reserve for internal assessment and the remaining 75 is for annual exam.

PHY 411: Mathematical Methods in Physics

1. Matrices and Tensors: Linear vector spaces, matrix spaces, linear independence, basis, dimension, linear operators, eigenvectors and eigenvalues, matrix diagonalization, special matrices, complete orthonormal sets of functions. Contra variant and covariant vectors and tensors, coordinate transformation of vectors, mixed tensor, inner product, quotient law, metric tensor.

2. Group Theory : Symmetries and groups, multiplication table and representations, permutation group, translation and rotation groups, O(N) and U(N) groups, generators of rotation and unitary groups, relation between SO(3) and SU(2).

3. Integral Transforms: Properties of Laplace transform, Inverse Laplace transform, LT of derivative and integral of a function. Fourier and inverse Fourier transforms, Properties of FT, Convolution theorem of LT and FT, Perceval's theorem. Application of LT and FT in solving differential equations.

Suggested Books:

1 G Arfken and Weber, Mathematical Methods for Physics.

2 A W Joshi, Matrices and Tensors for Physicists.

3 A K Ghatak, ChuDifferential Equations in Physics
4 K F Reily, M P Hobson and S J Bence, Mathematical Method for Physicists and Engineers.
5 P K Chattopadhyay : Mathematical Physics.

PHY 412: Classical Mechanics

1. Lagrangian Formulation of Mechanics

The variational principles and least action principles, Lagrangian equations of motion, constraints, Principle of virtual work and D'Alembert's principle, generalized coordinates, conjugate variables and phase space, symmetries and conservation laws.

2. Hamiltonian Formulation of Mechanics

Hamilton's equations, canonical transformations, Symplectic approach to canonical transformations, Poisson brackets, Liouville's theorem, Hamilton-Jacobi equation, action-angle variables,

3. Selected Classical Mechanics Topics

Rigid body motion (inertia tensors, Euler angles, rotation matrices) Small oscillations (normal modes, ordinary resonance, parametric resonances) Central force problems (the Kepler problem and scattering). Brief introduction to non-linear dynamics.

Suggested Books:

1. Goldstein, H., Classical Mechanics, Addison Wesley
2. Landau, L.D. And Lifshitz, E.M., A Course of Theoretical Physics, Vol I, Mechanics, Pergamon, NY.
3. Rana,N.C. and Joag, P.S., Classical Mechanics, Tata McGrawâ€• Hill Pub. Comp. Ltd., New Delhi.
4. Biswas, S.N., Clssical Mechanics, Books and Allied (P) Ltd, Kolkata.

PHY 413: Quantum Mechanics I

1. Basic Postulates of Quantum Mechanics. Interpretation of the eigenvalues eigenfunctions, expansion coefficients, expectation values, orthonormality, completeness, closure. Dirac bra and ket notation. Position and momentum representation of states and dynamical variables. Dirac δ function.

2. Commuting operators, compatibility and the Heisenberg Uncertainty Principle. Unitary transformation. Matrix representation of operators.Time evolution and Schrodinger equation. The Schrodinger and Heisenberg pictures.

3. Creation and annihilation operators. Operator algebra method of finding energy eigenvalues and Eigen states of the linear harmonic oscillator. System of identical particles. Symmetric and antisymmetric wave functions. Pauli's exclusion principle. Slater determinant.

4. Angular momentum in Quantum Mechanics: Commutation relations of angular momentum operators. Eigenvalues and eigenfunctions. Rotation and angular momentum.Matrix representation of angular momentum operators. Pauli spin matrices and their properties. Addition of angular momenta and the Clebsch Gordan coefficients.

Suggested Books:

1. B H Bransden & C J Joachain ,Quantum Mechanics ,Pearson Education, 2000.
2. R H Shankar, Principles of Quantum Mechanics , Springer 2008.
3. J J Sakurai, Modern Quantum Mechanics, Addition- Wessley, 1993.
4. B Craseman and J Powell, Quantum Mechanics, Addition-Wessley.
5. S Gasiorowicz, Quantum Physics, Wiley.
6. K.D. Krori, Principles of Non-Relativistic and Relativistic Quantum Mechanics, PHI Learning Pvt. Ltd., New Delhi, 2012.
7. N. Zettili, Quantum Mechanics
8. Desai, Quantum Mechanics

PHY 414: Electronic Devices

1. p-n junction

Energy Band Diagram; Forward and Reverse Bias; Full depletion analysis; Transient Response of P-n junction; Linearly graded junction; Abrupt p-i-n junction; Hetero p-n junction, Solar cell, Semiconductor laser, Light emitting diode.

2. Bipolar Transistors

Bipolar Junction Transistor: Principle of Operation; Current Components and Current Gain; Bias modes and operation of bipolar transistor; Ebers-Moll Model; BJT small signal equivalent circuit model; Heterojunction Bipolar Transistors.

3. Field Effect Transistors

JFET and MESFET:I-Vcharacteristics; arbitrary doping and enhancement mode, advanced device structures

MOS Capacitors: Surface Charge in Metal Oxide Semiconductor Capacitors; Capacitance-Voltage Characteristics of a MIS Structure; Capacitance-Voltage characteristics.

Metal Oxide Semiconductor Field Effect Transistors (MOSFETs): Gradual Channel Approximation and Constant Mobility Model; Charge Control Model; Threshold Voltage.

4. Digital Electronics

Basic digital concepts; Binary logic gates, binary arithmetic, number system. Basics and combinational logic gates; gate types and truth tables, Boolean algebra and DeMorgan's theorems, logic minimization and Karnaugh Maps, Multiplexing. Flip-Flops and introductory sequential logic. Counters, registers and state machines: Synchronous and asynchronous counters, basic and shift registers. Analogue to digital (A/D) and digital to analogue (D/A) convertors.

Suggested Books:

1. Digital Principles and applications: A P Malvino and D Leech, McGraw Hill Pubs.
2. Semiconductor Devices-Physics and Technology: S M Sze, John Willey Publications.
3. Measurement, Instrumentation and Experiment Design in Physics and Engineering, Prentice Hall Pubs. - Abhay Man Singh

PHY 415P: Lab 1 (Electronics and General)

1. Design and study of a Regulated Power Supply
2. Design and study of a Common Emitter Transistor Amplifier
3. To study the merits and demerits of different biasing techniques.
4. Multivibrators,

(i) Astable: To sketch the wave shape of astable multivibrator output for at least 3 different combinations of R and C and to compare the experimental result with the theoretical value.

(ii) Monostable: Using a square wave as the input to the monoshot, sketch the input in relation to the output of the monoshot for at least three different input frequencies.

5. Characteristics and applications of Silicon Controlled Rectifier.

(i) To plot the SCR characteristics under different gate current conditions and to obtain the values of the following parameters, (a) Forward break over voltage (VBRF) for specified gate current. (b) Forward ON voltage (VF)

(ii) To measure holding current (IH)

(iii) To study the effect of varying dc gate current on the firing point of the SCR connected as an ac rectifier.

6. Push-Pull Amplifier,

(i) To study the output waveforms of push-pull amplifier in different classes of operation and to measure the efficiencies in each case, and

(ii) To plot the frequency response of the amplifier operated at the class AB.

7. Modulation and Demodulation,

(i) To sketch the modulated waveform for at least two modulating signal frequencies and different indices of modulation.

(ii) To sketch the demodulated signal for a particular modulating signal and modulation index for three values of the RC time constant.

8. RC Coupled feedback amplifier,

To plot the frequency response for RC coupled feedback amplifier and hence to determine the band width (BW)

(i) without feedback,

(ii) with negative feedback, and

(iii) with positive feedback

(iv) To determine the signal handling capacities of the amplifier for each of the above three cases.

9. Sinusoidal Oscillators,

To study and measure the frequencies of oscillation for different values of R, L and C for

1. Phase shift,

2. Hartley's and

3. Colpitt's oscillators and compare with the theoretical values.

10. Testing goodness of fit of Poisson distribution to cosmic ray bursts by chi-square test.

11. To measure the wavelength of the unknown source using Michelson Interferometer.

12. To determine the velocities of ultrasonic waves in liquid medium using quartz oscillator.

13. To determine the velocity of sound using CRO

14. To determine the velocity of ultrasonic wave using ultrasonic interferometer

15. To determine the energy band gap in p-n junction diode.

16. Study of zener diode characteristics and zener regulated power supply

17. To verify Stefan's law and determination of Stefan's constant

18. Fourier analysis of given waveforms.

19. To measure the value of e/m of an electron using a magnetron valve.

20. To study the spectral distribution of energy in radiation at different temperatures (in visible range)

PHY 416: Quantum Mechanics II

1. Approximation Methods:

Time independent perturbation theory. Non degenerate and degenerate cases. Applications such as Stark Effect and Zeeman Effect. Variational methods, WKB approximation. Time dependent perturbation theory. Harmonic perturbation. Fermi's Golden rule. Adiabatic and sudden approximations. Semi-classical treatment of interaction of radiation with matter. Einstein's Coefficients. Spontaneous and stimulated emission and absorption.

2. Scattering Theory: Differential scattering cross section. Laboratory and CM reference frames. Partial wave analysis. Phase shift. Applications: scattering by a square well potential, perfectly rigid sphere, resonance scattering. Collision of identical particles. Born approximation. Green's function.

3. Relativistic quantum Mechanics: Klien-Gordon and Dirac equation. Properties of Dirac matrices. Free particle solution of Dirac equation.

Suggested Books:

1. B H Bransden & C J Joachain Quantum Mechanics, Pearson Education, 2000.
2. R H Shankar, Principles of Quantum Mechanics , Springer 2008.
3. J J Sakurai, Modern Quantum Mechanics, Addition-Wessley, 1993.
4. B Craseman and J Powell, Quantum Mechanics, Addition-Wessley.
5. S Gasiorowicz, Quantum Physics, Wiley.
6. K.D. Krori, Principles of Non-Relativistic and Relativistic Quantum Mechanics, PHI Learning Pvt. Ltd., New Delhi, 2012.

PHY 417: Statistical Physics

1. Classical Ensemble Theory:

Concept of phase space, Liouville's theorem, basic postulates of statistical mechanics, ensembles: microcanonical, canonical, grand canonical, partition function, Gibbs' paradox, equipartition theorem, virial theorem, energy and density fluctuations, applications of various ensembles.

2. Quantum Ensemble Theory

Density operator, Quantum Liouville's theorem, Density operator for equilibrium microcanonical, canonical and grand canonical ensembles, Fermi-Dirac and Bose-Einstein statistics. Grand partition functions.

3. Applications of Quantum Statistics:

(a) Ideal Bose gas: Properties of ideal Bose gas, Landau's theory of liquid He II, properties of black-body radiation, Bose-Einstein condensation, experiments on atomic BEC.

(b) Ideal Fermi gas: Properties of ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, white dwarf stars.

4. Introduction to non-equilibrium Statistical Mechanics

Brownian motion, Langevin equation, Einstein relation, Fokker-Planck equation, Diffusion equation Ising model.

Suggested Books:

1. R.K. Patharia - Statistical Mechanics
2. K. Huang - Statistical Mechanics
3. Landau & Lifshitz - Statistical Physics

PHY 418: Electrodynamics and Plasma Physics

1. Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors.

2. Reflection and refraction, polarization, Fresnel's Law, interference, coherence, and diffraction; Dispersion relations in plasma; Transmission lines and wave guides.

3. Lorentz transformation as 4-vector transformations; Electromagnetic field tensor; transformation of electro-magnetic fields; Covariance of Maxwell's equations; Dynamics of charged particles in static and uniform electromagnetic fields.

4. Retarded potential and Lienard-Wiechert potentials, Dipole radiation; Centre-fed linear antenna, Radiation from moving point charges, Power radiated by a point charge: Larmor's formula; Angular distribution of radiated power.

5. Basic Plasma Characteristics, The electron plasma frequency, The Debye length, Electrostatic plasma waves, Coulomb collisions. Motion of a charged Particle in Electric and magnetic fields, particle Drifts, Magnetic mirroring, Adiabatic Invariants. Waves in a Cold Plasma, General formulation, waves in a cold unmagnetized plasma, the dielectric tensor for a cold magnetized plasma, waves in a cold magnetized plasma.

Suggested Books:

1 David Griffiths: Introduction to Electrodynamics (Benjamin Cummings, 1999)
2 David K. Cheng: Field and Waves Electromagnetics (Addison-Wesley, 1999)
3 J.D. Jackson: Classical Electrodynamics (John Wiley & Sons, 1999)
4 K.Y.Singh: An Introduction to Electromagnetics (Mohit Publications: Delhi, 2009)
5 F.F.Chen: Introduction to Plasma Physics

PHY 419: Condensed Matter Physics

1. Crystal Physics and Defects in Crystals:

Crystalline solids, unit cells and direct lattice, two-and three-dimensional Bravais lattices, close packed structures

Interaction of X-rays with matter, absorption of X-rays, elastic scattering from a perfect lattice, the reciprocal lattice and its applications to diffraction techniques, powder method, crystal structure factor and intensity of diffraction maxima, extinctions due to lattice centering

Point defects, line defects and planar (stacking) faults, Observation of imperfections in crystals, X-ray and electron microscopic techniques

Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order, conducting polymers, quasicrystals

2. Electronic properties of solids:

Electrons in a periodic lattice, Bloch theorem, band theory, classification of solids, effective mass, tight binding, cellular and pseudopotential methods, Fermi surface, cyclotron resonance, magneto resistance, Hall effect, quantum Hall effect

Superconductivity, critical temperature, persistent current, Meissner effect, Weiss theory of ferromagnetism, Heisenberg model and molecular field theory spin waves and magnons, Curie - Weiss law for susceptibility, Ferri- and antiferromagnetic order, Domains and Bloch-wall energy

Suggested books:

1. Intoduction to Solid State Physics, C. Kittel
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin (BROOKS/COLE, 1976)
3. Crystallography for Solid State Physics, A.R. Varma and O.N. Srivastava
4. Condensed Matter Physics, M.P. Marder
5. Introduction to Solids, Azaroff

PHY 420P: Lab II (Electronics and Condensed Matter Physics)

1. Experiment on FET and MOSFET characterization and application as an amplifier.
   a. To measure Vp.
   b. To plot the output characteristics of the CS configuration.
   c. To plot the transfer characteristics and hence to obtain trans conductance
   d. To measure Vp
   e. To plot the output characteristics of the CS configuration.
   f. To plot the transfer characteristics and hence to obtain trans conductance (gm)
   g. To plot the frequency response of the CS FET amplifier with and without feedback.
2. Experiment on Uni-Junction Transistor and its application.
   i. To plot the input characteristics of UJT and to obtain the values of η, l_p, V_v, I_v, $V_{e(sat)}$
   ii. To plot the output characteristics of UJT and to obtain the value of RBB
   iii. To study the working of a UJT saw tooth generator
3. Digital I, Basic Logic Gates, TTL, NAND and NOR.
   Realization of Boolean expression using, (a) Different logic gates (b) Only universal building blocks (NAND/NOR)
4. Digital II, Combinational Logic.

Design a circuit using half adder by using NAND or NOR gates. Give specifications, truth table and Boolean equation.

5. Design a circuit using full adder by using gates. Give specifications, truth table and Boolean equation.
6. Design a four bit controlled invertor circuit by using XOR/NAND gates.
7. Design a circuit that can be used for addition and subtraction of two given four bit binary numbers using full adders and XOR/NAND gates. Explain its working and verify the result.
8. Flip-Flops.
9. Operational Amplifier (741).
    a. To measure the input bias, off-set currents and voltages etc.
    b. To measure the gain in the inverting amplifiers and to compare with the theoretical values. 10. 555 Timer

    To study 555 IC as a

    a. monoshot and hence to measure the pulse width,
    b. Long duration timer and hence to measure the duration, and
    c. Astable multivibrator and to measure the frequency of oscillation.
11. Electronic voltmeter
    i. To determine ,the percentage error for, the ordinary voltmeter and electronic voltmeter and to determine their internal resistances,
    ii. To plot the frequency response of the same.
12. Measurement of resistivity of a semiconductor by four probe method at different temperatures and Determination of band gap.
13. Determination of Lande's factor of DPPH using Electron-Spin resonance (ES.R.) Spectrometer.
14. Measurement of Hall coefficient of given semicoundutor, Identification of type of semiconductor and estimation of charge carrier concentration.
15. Determination of elm of electron by Normal Zeeman Effect using Febry Perot Etalon.
16. To determine the ionic magnetic moment of NiSO4 Quicke's method
17. To study the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.
18. To study Faraday Effect using He-Ne Laser.