Syllabus:-

PHYSICS
Grade: XI
Full marks: 100 (75T + 25 P)
Pass Marks: 27T + 8P
Teaching hours: 150T +50P
Nature of course: Theory +Practical

1. Introduction
The curriculum in Physics is designed to provide students with an understanding of the Scientific laws and principles of the physical world. As expected this curriculum will provide an opportunity to the students to see physics as a contribution to life in modern society. The course demands emphasis on conceptual understanding of the physical phenomena. This will involve the proper utilization of suitable mathematical models and equations. The applications of the physics together with the social and environmental aspects need to be emphasized whenever possible. The students are expected to actively participate in the learning process trough experimentation supplemented by demonstration, discussions and problem solving. The practical component of this course is designed to supplement learning through the application of the learned theory. The students will handle simple apparatus to do simple measurements, verifies physical laws and apply their knowledge of physics to real life example.

2. Objectives

2.1 General objectives
The general objectives of this course are:
a. to provide students with sufficient understanding and knowledge of the fundamental principles of physics and their applications;
b. to develop the skills of experimenting, observing, interpreting data evaluating evidence and formulating generalizations and models; and
c. to explain the social, economic, environmental and other implications of physics and appreciate the advancement of physics and its applications as essential for the growth of national economy.

2.2 Specific Objective
Upon completion of this course, the students will be able to:
1. describe physics as a coherent and developing framework of knowledge based on fundamental theories of the structure and process of the physical world;
2. explain phenomena in terms of theories and models;
3. apply quantitatively and qualitatively the knowledge and understanding of physical principles and theories;
4. translate information from one from to another;
5. present information in the language of physics or other appropriate form; and

6. design simple experiment to develop relations among physical quantities and draw conclusions.
3. Course contents

Unit -1 Mechanics 70 teaching hours

1. Physical Quantities – Need for measurements; system of units; S.I. unit; Precision and significant figures; Dimensions; Main uses of dimensional equations. (3 hrs)

2. Vectors-Graphical presentation of vectors; Addition and subtraction of vectors: Parallelogram, triangle and polygon laws of vectors; Resolution of vectors; Unit vectors; Scalar and vector products. (6 hrs)

3. Kinematics- Uniform and non-uniform motion; average velocity and acceleration, Instantaneous velocity and acceleration; Equation of motion (graphical treatment); Motion of a freely falling body; Relative velocity; Projectile motion. (3 hrs)

4. Laws of Motion-Newton’s laws of motion; Inertia, force, linear momentum, impulse, Conservation of linear momentum; Free-body diagrams; Solid frictions: Laws of solid friction and their verifications; Application of Newton’s laws: Particles in equilibrium, dynamics of particles. (8 hrs)

5. Work, and Energy -Work; work done by a constant force and a variable force; Power; Energy: Kinetic energy; work-energy theorem, Potential energy; conservation of energy; Conservative and non-conservative forces; elastic and inelastic collision. (4 hrs)

6. Circular Motion-Angular displacement, velocity and acceleration; Relation between angular and linear velocity and acceleration; Centripetal acceleration, centripetal force; Conical pendulum; Motion in a vertical circle; Motion of cars and cyclist round a banked track. (5 hrs)

7. Gravitation-Newton’s laws of gravitation; acceleration due to gravity, g; Mass and weight; gravitational field strength, variation in value of ‘g’ due to altitude, depth and rotation of earth; Weightlessness; Motion of a satellites: Orbital velocity, height and time period of a satellite, geostationary satellite, potential and kinetic energy of a satellite; Gravitational potential: Gravitational potential energy; Escape velocity; Black holes. (9 hrs)

8. Equilibrium- Moment of forces; Torque; Torque due to a couple; Center of mass; Center of gravity; Conditions of equilibrium. (2 hrs)

9. Rotational Dynamics- Rotation of rigid bodies; Equation of angular motion; Relation between linear and angular kinematics; Kinetic energy of rotation of rigid bodies; moment of inertia: Radius of gyration, Moment of inertia of a uniform rod; Torque and angular acceleration for a rigid body; Work and power in rotational motion; angular momentum; Conservation of angular momentum. (8 hrs)

10. Elasticity – Hooke’s law: Force constant, Verification of Hooke’s law; Stress; Strain; Elasticity and plasticity; Elastic modulus: Young modulus and its determination, Bulk modulus, Shear modulus, Poisson’s ratio, Elastic potential energy. (6 hrs)
11. Periodic motion – Oscillatory motion; Circle of reference; Equation of Simple Harmonic Motion (SHM); Energy in SHM; Application of SHM; Motion of a body suspended from coiled spring, angular SHM; simple pendulum; Damped oscillation; Forced oscillation and resonance. (6 hrs)

12. Fluid mechanics- Fluid statics: Density; Pressure in a fluid; Archimedes Principle; Buoyancy (3)
Surface tension: Molecular theory of Surface tension; Surface energy; Angle of contact and capillarity; Measurement of coefficient of surface tension by capillary tube method.
Fluid Dynamics: Newton’s formula for viscosity in a liquid; Coefficient of viscosity; Laminar and turbulent flow; Poiseuille’s formula (method of dimensions); Stokes law and its applications; Measurement of viscosity of viscous liquid; Equation of continuity; Bernoulli’s equation and its applications. (10 hrs)

Unit-2 Heat and thermodynamics 40 teaching hours

1. Heat and temperature- Concept of temperature; Thermal equilibrium,
Thermal expansion: linear expansion, cubical expansions and their relation:
Measurement of linear expansivity,
Liquid Expansion: Absolute and apparent expansion of liquid, Measurement of absolute expansivity by Dulong and Petit method. (5 hrs)

2. Quantity of heat: Heat capacity and specific heat capacity; Newton’s law of cooling;
Measurement of specific heat capacity of solids by the method of mixture and of liquids by the method cooling.
Change of phases: Latent heat; Specific latent heat of fusion, and vaporization and their measurements by the method of mixture. (5 hrs)

3. Thermal properties of matter- Equation of state: Ideal gas equation; P-V diagram;
Molecular properties of matter; Kinetic- molecular model of an ideal gas: Derivation of pressure exerted by gas, average translational kinetic energy of a gas molecule;
Boltzman constant, Root mean square speed; Heat capacities: heat capacities of gases and solids. (8 hrs)
4. Hygrometry- Saturated and unsaturated vapor pressure; Behavior of saturated vapor;
Boiling point; Triple point and critical point; Dew point, Absolute humidity; Relative humidity and its determination. (3 hrs)

5. Transfer of heat- Conduction, Thermal conductivity and its determination by Searle’s method;
Convection: convective coefficient
Radiation: Ideal radiator; Black body radiation; Stefan-Boltzmann law (4 hrs)

6. First law of thermodynamics- Thermodynamic systems; Work done during volume change, Heat and work; Internal energy and First law of thermodynamics;
Thermodynamic processes: Adiabatic, Isochoric, Isothermal, Isobaric processes; Heat
capacities of ideal gas at constant pressure and volume and relation between them; Isothermal and Adiabatic processes for an ideal gas. (9 hrs)

7. Second law of thermodynamics- Direction of Thermodynamic processes; Second law of thermodynamics; Heat engines; Internal combustion engines: Otto Cycle, Diesel cycle; Carnot cycle; Kelvin temperature scale; Refrigerators; Entropy and disorder (introduction only) (6 hrs)

Unit-3 Geometrical Optics 20 teaching hours

1. Photometry, Reflection at curved mirrors- Convex and concave mirrors; Image in Spherical mirrors, Mirrors formula; Real and Virtual images. (2 hrs)

2. Refraction at plane surfaces- Laws of refraction: Refractive index; Relation between refractive indices; Lateral shift; Total internal reflection and its applications; critical angle; optical fiber. (3 hrs)
3. Refraction through prisms- Minimum deviation; Relation between Angle of prism, minimum deviation and refractive index; Deviation in small angle prism. (3 hrs)

4. Lenses- Spherical lenses; thin lens formula; Lens maker’s formula; Power of a lens; Combination of thin lenses in contact. (4 hrs)

5. Dispersion- Spectrum; Spectrometer; Pure spectrum; Dispersive power; Achromatic lenses; Condition for achromatic lenses in contact, Chromatic aberration Spherical aberration; Scattering of light-blue color of the sky. (3 hrs)

6. Optical instruments- The human eye; Defects of vision and their correction; Visual angle; Angular magnification; Magnifier; Camera; Compound microscope, Astronomical Telescope (reflection and refractive type) (5 hrs)

Unit-4 Electrostatics 20 teaching hours

1. Electrostatics- Electric charge: Electric charges; Conductors and insulators; Charging by induction, Coulomb’s law- Force between two point charges, Force between multiple electric charges. (3 hrs)

2. Electric field- Electric fields; Calculation of electric field due to point charges; Field lines. Gauss Law: Electric Flux; Gauss Law and its application: Field of a charged sphere, line charge, plane sheet of charge. (7 hrs)

3. Potential: Potential and potential difference, Potential due to a point charge; Equipotential lines and surfaces; Potential gradient; Potential energy, Electron volt. (3 hrs)

4. Capacitance and dielectrics- Capacitance and capacitor; Charging and discharging of
capacitor through a resistor; Parallel plate capacitor; Combination of capacitors; Energy of charged capacitor; Effect of a dielectric; Molecular theory of induced charges; Polarization and displacement. (7 hrs)

A student will perform 20 experiments and 4 activities from the given list:

General instruction: Students are expected to learn general ideas of errors, order of accuracy and graphical analysis.

**List of Experiments**

**A. Mechanics**

1. Use of Vernier calipers:
   a. Determination of the length, the internal and external diameter of a given tube and calculation of its volume and density.
   b. Determination of the volume and density of a given rectangular block and verification of the results using a graduated cylinder.
   c. Determination of the internal diameter, depth and volume of a beaker or calorimeter.

2. Use of Spherometer:
   a. Determination of the thickness of a given rectangular thin glass plate and calculation of its area using a graduated cylinder.
   b. Determination of the radii of curvatures of a watch glass.
   c. Determination of the focal length of a spherical mirror

3. Use of Screw gauge:
   a. Determination of the diameter of a tube (or of a rod) and a small spherical bob and calculation of their densities.
   b. Determination of the length, volume and density of a tangle of wire.

4. Determination of the coefficient of friction for the two surfaces by (i) the horizontal plane method and (ii) an inclined plane method.

5. Verification of the principle of moments and the determination of a mass of a given body

6. Use of Simple pendulum:
   a. Determination of the length of a seconds pendulum and the value of ‘g’ in the laboratory.
   b. Verification of law of length and determination of the value of ‘g’ in the laboratory by log-log plot of time period versus length of the pendulum

7. Verification of Archimedes’ Principle and determination of the specific gravity of a solid heavier than and insoluble in water

8. Determination of the specific gravity of
   (a) A liquid
   (b) A solid lighter than and insoluble in water
(c) A solid heavier than and soluble in water

9. Use of Boyle’s law apparatus:
a. Verification of Boyle’s Law
b. Determination of the atmospheric pressure in the laboratory without reading a barometer and verification of the result by reading a barometer.

10. Use of Young’s modulus apparatus
a. Verification of Hooke’s Law
b. Determination of Young’s modulus of elasticity of the material of a given wire

11. Determination of the surface tension of water by capillary tube method.

12. Determination of the coefficient of viscosity of liquid by Stoke’s method

**B. Heat**

13. Calibration of a given thermometer and determination of the correct temperature of tap water.
14. Use of Pullinger’s apparatus
   Determination of the linear and cubical expansivity of a rod

15. Use of Regnault’s apparatus:
a. Determination of the specific heat capacity of a solid by the method of mixture.
b. Determination of the specific heat capacity of a liquid by the method of mixture.

16. Determination of the specific heat capacity of a liquid by the method of cooling.

17. Determination of latent heat of fusion of ice.

18. Determination of latent heat of vaporization of water.

19. Determination of the melting point of a solid by
   (i) Cooling curve method
   (ii) Capillary tube method

20. Determination of the thermal conductivity of a good conductor by Searle’s method.

**C. Geometrical Optics**

21. Reflection of light:
a. Verification of the laws of reflection of light.
b. Verification of the law of rotation of light.

22. Use of rectangular glass slab:
a. Verification of the laws of refraction of light.
b. Study of the variation of lateral shift with angle of incidence and determination of the thickness of the slab.
23. Use of Travelling Microscope:
Determination of the refractive index of glass slab

24. Determination of the refractive index of a prism by (i) symmetry method. (ii) I-D curve method.

25. Determination of the focal length of
   a. A concave mirror.
   b. A convex mirror

26. Determination of the focal length of
   a. A convex lens by double pin method
   b. A convex lens by displacement method

27. Determination of the focal length of a concave lens by using convex lens

28. Determination of the refractive index of the material of a plano-convex lens

**List of Activities**
1. To study the variation in the range of a jet of water with angle of projection
2. To study the effect of detergent on surface tension by observing the capillary rise
3. To study the factors affecting the rate of loss of heat of a liquid
4. To study the nature and size of the image formed by a convex lens using a candle and a screen.
5. To study the conservation of energy of a ball rolling on inclined plane.

Note: The above are only the specimens of activities. In order to arouse creativity, the students must be encouraged to take up new activities (other than mentioned above) in consultation with the teacher concerned.

**Laboratory Manual**
II. Elementary Practical Physics, Dr. Narayan Hari Joshi, TalejuPrakashan

**4. Teaching strategies:**
- Lecturing
- Group interaction
- Problem solving
- Demonstration
- Evaluation

**5. Instructional materials**
OHP, LCD, demonstration kits, writing boards etc.

**6. Evaluation Scheme (Theory)**
Unit Teaching Mark Distribution
Practical
Every student will perform at least 20 experiments and 4 activities during the academic year.

7. Evaluation Scheme for Practical examination:
One experiment 12 Marks
One activity 03 Marks
Practical record of experiments and activities 5 marks
Viva on experiment and activity 5 Marks

Total 25 Marks

Textbook:

Reference books:
Advanced Level Physics Tom Duncan, John Murray Ltd, 200

PHYSICS
Grade: XII
Full marks: 100 (75T + 25 P)
Pass Marks: 27T + 8P
Teaching hours: 150T +50P
Nature of course: Theory +Practical

1. Introduction
The curriculum in Physics is designed to provide students with an understanding of the scientific laws and principles of the physical world. As expected this curriculum will provide an opportunity to the students to see physics as a contribution to life in modern society. The course demands emphasis on conceptual understanding of the physical phenomena. This will involve the proper utilization of suitable mathematical models and equations. The applications of the physics together with the social and environmental aspects need to be emphasized whenever possible. The students are expected to actively participate in the learning process through experimentation supplemented by demonstration, discussions and problem solving.
The practical component of this course is designed to supplement learning through the application of the learned theory. The students will handle simple apparatus to do simple measurements, verifies physical laws and apply their knowledge of physics to real life example.
2. Objectives

2.1 General objectives
The general objectives of this course are:
a) to provide students with sufficient understanding and knowledge of the fundamental principles of physics and their applications;
b) to develop the skills of experimenting, observing, interpreting data evaluating evidence and formulating generalizations and models; and
c) to explain the social, economic, environmental and other implications of physics and appreciate the advancement of physics and its applications as essential for the growth of national economy.

2.2 Specific Objective
Upon completion of this course, the students will be able to:
1. describe physics as a coherent and developing framework of knowledge based on fundamental theories of the structure and process of the physical world;
2. explain phenomena in terms of theories and models;
3. apply quantitatively and qualitatively the knowledge and understanding of physical principles and theories;
4. translate information from one from to another;
5. present information in the language of physics or other appropriate form; and
6. design simple experiment to develop relations among physical quantities and draw conclusions.

3. Course Content

Unit-1 Waves and Optics 40 Teaching Hours

Waves (23 Hrs)
1. Wave motion- Wave motion; Longitudinal and transverse waves; Progressive and stationary waves; Mathematical description of a wave. (4 hrs)

2. Mechanical waves- Speed of wave motion; Velocity of sound in solid and liquid; Velocity of sound in gas; Laplace’s correction; Effect of temperature, pressure, humidity on velocity of sound. (5hrs)

3. Wave in pipes and strings- Stationery waves in closed and open pipes; Harmonics and overtones in closed and open organ pipes; End correction in pipes; Resonance Tube experiment; Velocity of transverse waves along a stretched string; Vibration of string and overtones; Laws of vibration of fixed string. (6 hrs)

4. Acoustic phenomena- Sound waves: Pressure amplitude; Characteristics of sound: Intensity; loudness, quality and pitch; Beats; Doppler’s effect; Infrasonic and ultrasonic waves; Noise pollution: Sources, health hazard and control. (8 hrs)

Unit-2 Electricity and Magnetism 55 Teaching Hours

Current Electricity (20 Hrs)
1. D.C. Circuit- Electric Currents; Drift velocity and its relation with current; Ohm’s law; Electrical Resistance; Resistivity; Conductivity; Super conductors; Perfect Conductors; Current-voltage relations; Ohmic and Non-Ohmic resistance; Resistances in series and parallel, Potential Divider, Conversion of galvanometer into voltmeter and ammeter, Ohmmeter; Electromotive force: Emf of a source, internal resistance; Work and power in electrical circuits; Joule’s law and its verification. (9 hrs)

2. Electrical circuits-Kirchhoff’s laws; Wheatstone bridge circuit; P.O.Box, Meter Bridge; Potentiometer; Comparison of e.m.f’s., measurement of internal resistance of a cell. (7 hrs)

3. Thermoelectric Effect- Seebeck Effect; Thermocouples, Peltier effect: Variation of thermoelectric emf with temperature, Thermopile, Thomson effects. (2 hrs)

4. Chemical effect of current- Faraday’s laws of electrolysis; Faraday’s constant, Verification of Faraday laws of electrolysis. (2 hrs)

**Magnetic Field of current (35 Hrs)**

1. Magnetic Field-Magnetic field lines and magnetic flux; Oersted’s experiment; Force on moving charge, Force on Conductor; Force and Torque on rectangular coil, Moving coil galvanometer; Hall effect; Magnetic field of a moving charge; Biot and Savart law and its application to (i) a circular coil (ii) a long straight conductor (iii) a long solenoid; Ampere’s law and its application to (i) a long straight conductor (ii) a straight solenoid (iii) a toroidal solenoid; Forces between two parallel conductors carrying current definition of ampere. (14 hrs)

2. Magnetic properties of materials-Elements of earth magnetism and their variation; Dip and Dip circle; Flux density in magnetic material; Relative permeability; Susceptibility; Hysteresis, Dia-,Para- and Ferro-magnetic materials. (5 hrs)

3. Electromagnetic Induction-Faraday’s laws; Induced electric fields; Lenz’s law, Motional electromotive force; AC generators; eddy currents; Self inductance and Mutual inductance; Energy stored in an inductor; Transformer. (8 hrs)

4. Alternating Currents- Peak and RMS Value of AC current and Voltages, AC through resistor, capacitor and inductor; Phasor diagram, Series circuits containing combination of resistor, capacitor and inductor; Series Resonance, Quality factor; Power in AC circuits: Power factor; choke coil. (8 hrs)

**Unit-3 Modern Physics 55 teaching hours**

1. Electrons and Photons-Electrons: Milikan’s oil drop experiment, Gaseous discharge at various pressure; Cathode rays, Motion of electron beam in electric and magnetic fields; Thomson’s experiment to determine specific charge of electrons. Photons: Quantum nature of radiation; Einstein’s photoelectric equation; Stopping
Potential; Measurement of Plank’s constant, Milikan’s experiment (10 hrs)

2. Solids and Semiconductor devices- Structure of solids; Energy bands in solids (qualitative ideas only); Difference between metals, insulators and semi-conductors using band theory; Intrinsic and extrinsic semi-conductors; P-N Junction; Semiconductor diode: Characteristics in forward and reverse bias; Full wave rectification; Filter circuit; Zener diode; Transistor: Common emitter characteristics, Logic gates; NOT, OR, AND, NAND and NOR. , Nanotechnology(introductory idea) (11 hrs)

3. Quantization of energy-Bohr’s theory of hydrogen atom; Spectral series; Excitation and ionization potentials; Energy level; Emission and absorption spectra, De Broglie Theory; Duality; Uncertainly principle.
X-rays: Nature and production; uses: X-rays, X-rays diffraction, Bragg’s law. (9 hrs)

4. Nuclear physics- Nucleus: Discovery of nucleus; Nuclear density; Mass number; Atomic number; Atomic mass; Isotopes; Einstein’s mass-energy relation, Mass Defect; Binding energy; Fission and fusion. (6 hrs)

5. Radioactivity- Alpha-particles; Beta-particles, Gamma rays; Laws of radioactive disintegration; Half-life and decay constant; Geiger-Muller Tube; Radio carbon dating; Medical use of nuclear radiation; Health hazards and safety precautions. (7 hrs)
6. Nuclear energy and other sources of energy- Sources of energy; Conservation and degradation of energy; Transformation of energy.
Nuclear energy: Energy released from fission and fusion; Thermal and Hydroelectric power; Wind energy; Biofuels; Solar energy; Solar constant; Solar devices; Global energy consumption pattern and demands; Energy use in Nepal.
Fuels and pollution: Global Warming; Acid rain. (9 hrs)

7. Particle physics and cosmology- particles and antiparticles, Quarks and Leptons, baryons, mesons.
Universe- Hubble law; Big Bang; Critical density; Dark matter, (3 hrs)

Practical
A student will perform at least 24 experiments from the given list:

Introduction
General instruction: Students are expected to learn general ideas of errors, order of accuracy and graphical analysis. Students are also expected to learn the physical principles and theory of experiments on magnetism not covered in the theory curriculum.

List of experiments

A. Wave and Optics
1. Determination of the wavelength of sodium light by measuring the diameter of
Newton’s rings.

2. Determination of the wavelength of a given monochromatic source of light by passing a plane diffraction grating.

3. Determination of the refractive index of a given transparent medium and calculation of the speed of the light in the medium.

4. Uses of laser beams:
   i Determination of the wavelength of He-Ne laser light
   ii Determination of the diameter of a given hair

5. Uses of Sonometer:
   i Determination of the frequency of a given tuning fork
   ii Comparison of frequencies of two tuning forks

6. Determination of the frequency of A.C. Mains.

7. Use of Resonance tube:
   i Determination of velocity of sound in air at NTP
   ii Comparison of frequencies of two tuning forks

8. Determination of the end correction of the resonance tube apparatus.

**B. Electricity**

9. Verification of Ohm’s Law

10. Use of P.O. Box:
    i Determination of the resistivity of the material of a given wire
    ii Verification of the laws of series and parallel resistances

11. Use of meter bridge:
    i Comparison of resistances of two given wires
    ii Determination of the resistivity of the material of a given wire
    iii Verification of the laws of series and parallel resistances

12. Determination of high resistance by substitution method.

13. Determination of the capacitance of the capacitor by charging and discharging a capacitor.

14. Use of potentiometer:
    i Comparison of emf’s of two cells
    ii Comparison of resistances of two given wires
    iii Determination of the internal resistance of a cell
15. Conversion of given galvanometer into an ammeter and a voltmeter of desired range.


17. Determination of the half-life of a circuit containing a pure capacitor in series with a resistance in a D. C. circuit.

18. Uses of a series LCR circuit:
   i Determination of the resonant frequency of a series LCR circuit
   ii Determination of the quality factor of a series LCR circuit

C. Magnetism

19. Determination of the pole strength and magnetic moment of a bar magnet by locating the neutral points keeping:
   i North pole pointing towards the geographical south
   ii North pole pointing towards the geographical north

20. Use of deflection magnetometer:
   i Determination of the pole strength and magnetic moment of a bar magnet
   ii Comparison of the magnetic moments of two bar magnets

21. Use of oscillation magnetometer:
   i Determination of the pole strength and magnetic moment of a bar magnet
   ii Comparison of the magnetic moments of two bar magnets

22. Use of dip circle: Determination of the angle of dip in the laboratory

D. Modern Physics

23. Study the characteristics of a junction diode.

24. Study the characteristics of a transistor.

25. Study the characteristics of a Zener diode.

26. Determination of Planck’s constant using a photocell

14

List of Activities
1. To assemble a household circuit comprising three bulbs, three switches, a fuse and a power source. Measure current and voltage across each component and then interpret the data.

2. Use of multimeter to (a) identify base of transistor and terminal of IC (b) Check whether a given electronic component (e.g. diode, transistor, and IC) is in working order.
3. To study the relation between frequency and length of a given wire under constant tension using sonometer.

4. Study of AND, OR, and NOT gates.

5. To identify the difference between e.m.f. and p.d. of a cell.
Note: The above are only the specimens of activities. In order to arouse creativity, the students must be encouraged to take up new activities (other than mentioned above) in consultation with the teacher concerned.

Laboratory Manual

II. Elementary Practical Physics, Dr. Narayan Hari Joshi, TalejuPrakashan

4. Teaching strategies:
   • Lecturing
   • Group interaction
   • Problem solving
   • Demonstration
   • Evaluation

5. Instructional materials
   OHP, LCD, demonstration kits, writing boards etc.

6. Evaluation Scheme

Unit Teaching Mark Distribution

<table>
<thead>
<tr>
<th>Hours</th>
<th>LAQ</th>
<th>SAQ</th>
<th>NP</th>
</tr>
</thead>
</table>

Practical
Every student will perform at least 20 experiments and 4 activities during the academic year.

7. Evaluation Scheme for Practical examination:
One experiment 12 Marks
One activity 03 Marks
Practical record of experiments and activities 5 marks
Viva on experiment and activity 5 Marks

Total 25 Marks

Text book:
Reference books:

B.Sc. First year

Course of Study

Tribhuvan University
Institute of Science and Technology

Course Title: (Mechanics, Thermodynamics and Statistical Physics, Electricity and Magnetism)
Course No.: Phy 101
Nature of Course: Theory
Year: 1

Full Marks: 100
Pass Marks: 35

Course Objectives
At the end of this course the student should be able:
- to acquire sufficient basic knowledge in physics
- to apply this knowledge for higher studies and research in physics
MECHANICS:

Review of Laws of Motion:
Dynamics of a particle, General equations of motion, Types of forces, Conservation laws, Work-Energy theorem, Conservative forces, Motion of a body near the surface of the earth, Linear restoring force, Potential energy curve, Non-conservative forces. (2 hrs)

Linear and Angular Momentum:
Conservation of linear momentum, Centre of mass, Collision of two particles, Deflection of a moving particle by a particle at rest, Rocket, Angular momentum and torque, Motion under central force, Areal velocity, Examples of conservation of angular momentum. (4 hrs)

Gravitational Potentials and Fields:
Central Forces, Inverse square-law of force, Gravitational field and potential, Velocity of escape, Potential and field due to a thin spherical shell and due to a solid sphere, Gravitational self energy, Gauss’s and Poisson’s equation for gravitational field, Kepler's laws of planetary motion, Deduction of Newton’s law of gravitation from Kepler’s Laws. (6 hrs)

Dynamics of Rigid Bodies:
Equations of motion for a rotating rigid body, Theorems on moment of inertia (M.I.), M.I. of a rectangular lamina, Solid uniform bar of rectangular cross-section, Circular disc, Solid cylinder, Solid sphere and spherical shell, Kinetic energy of a rotating and rolling bodies, Motion of a body rolling down an inclined plane, Reduction of two body problem to a single body problem. (6 hrs)

Harmonic Oscillator:
Simple harmonic motion (S.H.M.) and harmonic oscillator, Examples of harmonic oscillator, Simple pendulum, Compound pendulum, Mass-spring system, Torsional pendulum, Helmholtz resonator, Oscillation of two particles connected by a spring, N-coupled oscillators, Damping force, Damped and forced harmonic oscillator, Power dissipation, Quality factor, Power absorption. (10 hrs)

Wave Motion:
General equation of wave motion, Equation of plane progressive harmonic wave, Particle velocity and wave velocity, Energy density for a plane progressive wave, Intensity of wave and spherical waves, Transverse waves in stretched strings, Modes of vibration, Longitudinal waves in rods and gases, Flow of energy in stationary waves. (8 hrs)

Elasticity:
Relations connecting various elastic constants, Angle of twist and angle of shear, Twisting couple on a cylindrical rod or wire, Work done in twisting a rod or wire, Bending of beams, Bending moment, Cantilever, Beam supported at its ends and loaded in the middle. (8 hrs)

Fluid Mechanics - Viscosity:
Kinematics of moving fluid, Equation of continuity, Bernoulli's theorem and its applications, Viscous fluids, Streamline and turbulent flow, Critical velocity, Reynold's number, Poiseuille's equation, Capillaries in series and parallel. (6 hrs)

THERMODYNAMICS:

Thermodynamic Fundamental Concepts:
Thermodynamic systems, Thermal and thermodynamic equilibrium, Equation of state, Thermodynamic processes, External and internal work, Internal energy, Quasi-static, Isothermal, Adiabatic, Isobaric and isochoric processes. (2 hrs)

Laws of Thermodynamics and Their Application:
Zeroth law, First law of thermodynamics, Second law of thermodynamics, Carnot’s theorem, Absolute scale of temperature, Entropy changes in reversible and irreversible processes, Principle of increase of entropy, Entropy and second law, Third law of thermodynamics and its applications. (6 hrs)

Thermodynamic Relations:
First and second latent heat equations, Triple point, Thermodynamic potentials, Helmholtz’s function, Enthalpy, Gibb’s function, Maxwell’s thermodynamic relations, Phase transition, Clausius-Clapeyron equation. (6 hrs)

Concept of Ideal and Real Gases:
Concept of ideal and real gases, Joule expansion, Joule’s law for perfect gas, van der Waals equation, Critical constants of van der Waals gas, Joule-Thomson expansion, Porous plug experiment, Constancy of enthalpy, Adiabatic expansion. (5 hrs)

Production of Low Temperature:
Thermodynamics of refrigeration, Refrigeration cycle, Co-efficient of performance, Cooling in Joule-Thomson expansion, Regenerative cooling, Cascade cooling, Boyle’s temperature of inversion, Critical temperature and their relations, Liquefaction of Helium and its properties. (5 hrs)

Transport Phenomenon:
Molecular collisions, Collision cross-section, Molecular diameter, Mean free path, Transport phenomenon, Transport of momentum - viscosity, Transport of energy - thermal conductivity, Transport of mass - diffusion, Brownian motion, Einstein’s theory of Brownian motion. (5 hrs)

**Black Body Radiation:**
Total energy density, Spectral energy density, Emissive power, Absorptive power, Kirchoff’s law, Pressure of radiation, Pressure of diffusive radiation, Stefan-Boltzmann’s law, Spectrum of black body radiation, Wien’s displacement law, Planck’s radiation law, Rayleigh-Jean’s law. (6 hrs)

**STATISTICAL PHYSICS:**

**Classical statistical physics:**
Phase space, Microstate, Macrostate, Ensemble, Constraints and accessible states, Thermodynamic probability, Fundamental postulates of statistical mechanics, Division of phase space into cells, Boltzmann’s canonical distribution law, Maxwell’s distribution law of velocities, Maxwell-Boltzmann statistics, Law of equipartition of energy. (10 hrs)

**Introduction to Quantum Statistical Physics:**
Bose-Einstein statistics, Fermi-Dirac statistics, Black body radiation, Electron gas in metals, Fermi energy. (5 hrs)

**ELECTRICITY and MAGNETISM**

**Elementary Vector Analysis:**
Gradient of a scalar, Divergence and curl of a vector in cartesian coordinates, Divergence in polar coordinates, Gauss's, Stoke's and Green's theorems, Laplacian in polar co-ordinate system, Laplace's and Poisson's equation. (5 hrs)

**Electrostatic Potential and Field:**
Coulomb's law, Electric Potential energy of a system of charges, Electric field strength, Electric flux, Gauss's law and its applications, Electric potential and the line integral of the electric field, Equipotential surface, Potential and field due to an electric dipole, Potential due to an infinitely long charged wire, Potential and field due to an uniformly charged disc, Force on a surface charge, Method of electrical images. (7 hrs)

**Electric Fields in Dielectrics:**
A dipole in an electric field, Polar and non-polar molecules, Dielectric polarization, Electric field due to a polarized dielectric (three electric vectors), Gauss's law in dielectric, Energy stored in an electric field in the presence of dielectric, Boundary conditions on field vectors, Molecular field in a dielectric, The Clausius-Mossotti relation, Polar molecules, The Langevin Debye formula. (6 hrs)

**Magnetic Fields of Moving Charges:**
Magnetic field and the magnetic flux, Biot-Savart's law and its applications, Lorentz force, Ampere's circuitual law and its applications, Curl $\mathbf{B}$ and div $\mathbf{B}$, Magnetic vector and scalar potentials, Magnetic dipole, Force between current carrying parallel wires. (6 hrs)

**Magnetic Properties and Fields:**
The absence of isolated magnetic poles, Magnetic dipole moment of current loop and angular momentum, Magnetization, Langevin's theory of diamagnetism and paramagnetism, Theory of ferromagnetism, Energy loss due to hysteresis, Magnetic susceptibility and permeability, Ferrites. (6 hrs)

**Electromagnetic Inductions:**
Faraday's law, Skin effect, Moving coil ballistic galvanometer, Search coil, Flux meter, Earth inductor, Self and mutual induction, Reciprocity theorem of mutual inductances, Self inductance of a solenoid, Toroid and two long parallel wires, Energy stored in magnetic field, Transformer. (4 hrs)

**Varying Currents:**
Charging and discharging of a condenser through a resistance, Rise and decay of current in LR circuit, LC circuit, Charging and discharging of a capacitor through inductance and resistance. (3 hrs)

**Alternating Current Circuit:**
The complex number method for AC analysis, Impedance, Reactance and admittance, LCR circuits, Phase diagrams, Sharpness of resonance, Quality factor, Power factor. (3 hrs)

**Maxwell's Electromagnetic Equations:**
The displacement current, Maxwell's equations and their use in propagation of electromagnetic wave, Poynting vector, Derivation of Gauss's theorem, Faraday's law, Lenz law, Biot-Savrat's law and Ampere's circuitual law, Energy of a charged particle in an electromagnetic field, Reflection and refraction of electromagnetic waves at the interface between two media, Plane wave solution of Maxwell’s equations, The wave equation, Plane electromagnetic waves in isotropic dielectric and in conducting media. (10 hrs)
Text Books:

Reference Books:
Course Title: Physics Laboratory
Course No. Phy 102 (Major/Minor both)
Nature of course: Practical

Course Objectives:
At the end of the practical course the students will be able:
- to relate theoretical concepts to practical skills
- to perform laboratory work and
- to perform major laboratory courses
- to set experiments related to physics
- to design laboratory experiments
- to draw conclusions from laboratory work
- to develop proper laboratory skills
- to interpret laboratory work results

Experiments: (75 hrs.): (A minimum of 10 Experiments must be performed by each student)
Probability and statistical analysis of data*:

1. To verify laws of probability by throwing coins.
2. From given set of data, calculate the standard deviation, standard error and probable error with significant figures.
3. From given set of observed and theoretical data of an experiment, test how well the data are in this experiment.
4. By using method of least square, draw the best straight line through a set of given data points with error bar and find the error in slope.
*Data for experimental analysis to be provided by concerned department.

Mechanics Experiments:
5. To determine the moment of inertia of a flywheel.
6. To determine the angular acceleration of a flywheel.
7. To determine the value of acceleration due to gravity by using Bar Pendulum /Kater’s pendulum.
8. To determine the Young’s modulus of the material by bending beam method.
9. To determine the surface tension of liquid by Jaeger’s method.
10. To determine of modulus of rigidity of wire by torsion pendulum/Maxwell’s vibration needle.
11. To determine the coefficient of viscosity of water by Poiseulle’s method.

**Thermodynamics Experiment:**
12. To determine the value of Stefan’s constant.
13. To determine the ratio of $C_p$ and $C_v$ by Clement and Desorme’s apparatus.
14. To find the co-efficient of thermal conductivity of a bad conductor by Lee’s method.
15. To determine the mechanical equivalent of heat by Callender and Barne’s constant flow method.

---

**Tribhuvan University**

**Institute of Science and Technology**

**Course Title:** Physics Laboratory

**Course No.** Phy 103 (Major/Minor both)

**Nature of course:** Practical

**Year:** I

**Full Marks:** 25

**Pass Marks:** 10

**Experiments: (75 hrs.):** (A minimum of 10 Experiments must be performed by each student)

**Electricity and Magnetism Experiments:**
1. To determine the sensitivity and constant of Ballistic galvanometer.
2. To determine the capacitance by Ballistic galvanometer.
3. To determine the high resistance by the method of leakage.
4. To determine the low resistance by Carey Foster bridge.
5. To determine the magnetic field using search coil.
6. To determine the dip using earth inductor.
7. To determine the impedance of LCR series circuit.
8. To determine the resonant frequency and quality factor of series LCR circuit.
9. To determine the time constant for RL, RC and LCR circuit.
10. To determine the efficiency of an electric kettle (or heating element) under varying input voltages.
11. To determine the capacitance of a capacitor by ac bridge (de-Sauty’s method).
12. To determine the inductance of an inductor by Maxwell inductance-capacitance bridge.
13. To determine the coefficient of mutual inductance of two coils.
14. Compare the B-H characteristic curves for two different materials (Hysteresis curves).
15. Determine the unknown frequency of a given source by using Lissajous figure.
Text Books:

Note:

a. Student must perform three periods laboratory work twice a week to complete both Phy 102 and Phy 103.

b. Practical courses Phy 102 and Phy 103 each will be examined for the duration of three hours. Students must pass both courses separately.

c. The practical exam will be graded on the basis of the following marking scheme:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record file</td>
<td>20%</td>
</tr>
<tr>
<td>Experiment</td>
<td>60%</td>
</tr>
<tr>
<td>Viva</td>
<td>20%</td>
</tr>
</tbody>
</table>

B.Sc. Second year

Tribhuvan University
Institute of Science and Technology
Four Years B.Sc. (Physics) - Course of Study
2070

Course Title: (Optics, Modern Physics, Electronics)
Course No: Phy.201 (Major/Minor)                Full Marks: 100
Nature of Course: Theory                  Pass Marks: 35
Year: II

Course Objectives
At the end of this course the students will be able:

- to acquire sufficient basic knowledge on such topics in Physics as Optics, Modern Physics and Electronics.
- to apply their knowledge to learning major courses.
- to solve mathematical problems related to the topics.
- to deduce mathematical relations and formulas.

OPTICS

Wave Nature of Light: Nature of light, Huygen's wave theory and its application for propagation of waves (2 hrs.)

Aberration at Spherical Surfaces: Refraction through spherical surfaces from Huygen's wave theory, chromatic aberrations; astigmatism, coma, curvature, distortion and their elimination, Ramsden's and Huygen's eyepieces (7 hrs.)

Interference: Condition for obtaining interference, spatial and temporal coherence, interference by division of wave front, Fresnel’s biprism, Lloyd’s mirror, division of amplitude, thin and wedge films, Newton’s ring, Michelson interferometer, Fabry Perot
**Diffraction:** Huygen’s principle, Fresnel and Fraunhoffer diffraction, Fresnel’s diffraction: zone plate, circular aperture, straight edge, disc. Fraunhoffer’s diffraction: diffraction through a single and double slit, circular aperture and disc, dispersive and resolving power of grating, microscope and telescope (11 hrs.)

**Polarization:** Unpolarized plane, circular and elliptically polarized light, double refraction, crystal polarizer, Malus law, polarization by reflection and scattering, double refraction and Huygen’s explanation, production and analysis of polarized light, optical activity, Laurent half shade polarimeter and its applications (8 hrs.)

**Dispersion and Scattering:** Dispersion of a Prism, Normal and anomalous dispersion, Cauchy’s equation, scattering of light, Scattering by small particles, Scattering and Refractive Index, Raman Effect (4hrs.)

**Lasers:** Spontaneous and stimulated emission, conditions for laser action, population Inversion, optical pumping, Ruby and He-Ne lasers and applications (4 hrs.)

**Holography:** Basic principles of holography, applications (3 hrs.)

**Text Books:**

**References:**

**MODERN PHYSICS**

**Atomic Structure:** The nuclear atom, Rutherford scattering and its conclusions, limitations of Rutherford model of atom, electron orbits, atomic spectra, the Bohr’s atom, energy level diagram and spectra of hydrogen atom, Frank-Hertz experiment and limitations of Bohr’s model, the Sommerfeld atom (8 hrs.)

**Many Electron Atom:** Electron spin, the Stern-Gerlach experiment, Pauli’s exclusion principle, shells and subshells of electrons, vector atom model, LS coupling and s, p, d, f notation (5 hrs.)

**Atomic Spectra:** Fine structures of H, Na, He and Hg, Paschen-Back effect, Stark effect, normal and anomalous Zeeman effect (7 hrs.)

**Particle properties of waves:** Electromagnetic waves and its interaction with matter, absorption, photoelectric effect, Compton scattering, pair production, photons and gravity (6 hrs.)

**X-ray Spectrum:** Characteristic X-ray, X-ray diffraction and spectrometer, fine structure of X-ray transitions, Moseley's law and its application (4 hrs.)
**Nuclear Structure:** Proton-electron and proton-neutron hypothesis, nuclear composition and its properties (mass, charge, density, magnetic and electric properties), nuclear stability and binding energy, Meson theory of nuclear forces (6 hrs.)

**Nuclear Transformations:** Radioactivity, law of radioactive disintegration, law of successive disintegration, half-life, mean life, natural radioactive series, alpha, beta and gamma ray spectra, absorption of α particles, range, straggling and stopping power, theory of α decay, neutrino hypothesis of β-decay, biological effects of ionizing radiation (7 hrs.)

**Particle Detectors and Accelerators:** Ionization chamber, G. M. counter, scintillation counter, bubble chamber, Cerenkov detectors, semiconductor detectors, linear accelerator, cyclotron, synchrocyclotron, betatron, the LHC project (7 hrs.)

**Text Books:**

**References:**

**ELECTRONICS**

**Network Theorems:** Superposition Theorem, Ideal constant-voltage source, Ideal constant-current source, Thevenin’s and Norton’s Theorem and their applications, maximum power transfer theorem 4 hrs

**Semiconductor and Diodes:** Review of semiconductor, types of semiconductor, energy bands in semiconductors, Different types of diodes, P-N junction diode characteristics, application of junction diode as half wave and full wave rectifier, bridge rectifier, R-C filter, ripple factors, zener diode and its application in voltage regulation circuit 6 hrs

**Bipolar Junction Transistors:** PNP and NPN transistors, transistor input, output and transfer characteristics in different configurations, α and β of transistor, transistor biasing, load lines, Q-point, optimum Q-point, bias stabilization, stability factor, CB, CE, and CC amplifiers and their DC and AC equivalent circuits, amplifier gain (voltage, current, power) calculations, AC input and output impedances of different amplifiers, phase inversion in CE amplifier 10 hrs

**Amplifiers:** Cascaded amplifiers, R-C coupled amplifier, overall voltage gain, frequency response, power amplifiers. 4 hrs

**Operational amplifiers:** Differential amplifiers, ac analysis of differential amplifier, differential gain, input impedance, common mode gain, common mode rejection
ratio (CMRR), Op-Amp, inverting and non-inverting mode of Op-Amp. 5 hrs

**Feedback Amplifier:** Introduction of feedback and their types, Negative feedback and positive feedback, advantages of negative voltage feedback, different types of feedback amplifier (Voltage-series feedback, voltage shunt feedback, current series feedback, current shunt feedback) 4 hrs

**Oscillators:** Barkhausen criterion, working principle of Hartely, colpitt’s and phase shift oscillators, Multivibrators and their working principle. 5 hrs

**FET and UJT:** Field effect transistor, its characteristics, FET as an amplifier with infinite input impedance. Unijunction transistor and its characteristics, UJT as a relaxation oscillator 4 hrs

**Digital Electronics and Logic gates:** Decimal, Binary, Octal and Hexadecimal number of systems and their interconversion, Addition and subtraction of binary numbers, Boolean algebra and de Morgan’s theorem, OR, AND, NOT, NOR, NAND, X-OR and X-NOR gates NOR and NAND gate as basic building block, Half adders and full adders, RS, JK, D-flip flops. 8 hrs

**Text book:**

**Reference books:**
- Basic Electronics, B. L. Theraja, S.Chand&co.Ltd., New Delhi
- Principles of Electronics, V. K. Mehta and Rohit Mehta, S. Chand &co.Ltd., New Delhi

**Course Title:** Physics Laboratory

**Course Objectives**
At the end of the practical course the students will be able:
- to relate theoretical concepts to practical skills
- to perform laboratory work
- to perform major laboratory courses
- to set experiments related to physics
- to design laboratory experiments
- to draw conclusions from laboratory work
- to develop proper laboratory skills
- to interpret laboratory work results

**Course No.** Phy 202 (Major/Minor both) **Full Marks:** 25

**Nature of course:** Practical **Pass Marks:** 10

**Year:** 1

**Experiments:** (75 hrs.): (A minimum of 10 Experiments must be performed by each student)

**Optics Experiments:**
1. To determine the wave length of given source of light by Newton's Ring method.
2. To determine the wavelength of given source of light by Fresnel's Bi-Prism.
3. To determine the wavelength of given source of light using a plane diffraction grating.
4. To determine the resolving power of a prism.
5. To determine the resolving power of a plane transmission diffraction grating.
6. To determine the refractive index of the material of a prism for light of different wavelengths.
7. To determine the value of Cauchy’s constants for the material of the given prism using a spectrometer.
8. To determine the specific rotation of sugar solution using Laurent half-shade polarimeter

**Modern Physics Experiments:**
9. To determine the charge of an electron by Millikan’s method.
10. To determine the specific charge of an electron (e/m) by magnetron tube method.
11. To determine the specific charge of an electron (e/m) by Thomson’s method.
12. To study the absorption of X-ray by the materials.
13. To study the characteristics of Geiger Muller (G.M.) counter and its reliability.
14. To determine the half-life period of a given radioactive substance using a G.M. counter.
15. To determine the linear absorption coefficient of β-particles in a matter using a G.M. counter.

**Course No.** Phy 203 (Major/Minor both) **Full Marks:** 25  
**Nature of course:** Practical **Pass Marks:** 10  
**Year:** 1  
**Experiments:** (75 hrs.) (A minimum of 10 Experiments must be performed by each student)  
**Electronics Experiments:**  
1. To study oscilloscope and calibrate it for the measurement of voltage and frequency.  
2. To verify the maximum power transfer theorem.  
3. To verify the network theorems: Thevenin's theorem and Norton's theorem.  
4. To study the common base characteristics of a PNP and NPN junction transistor.  
5. To study the common emitter characteristics of a PNP and NPN junction transistor.  
6. To study the common collector characteristics of a PNP and NPN junction transistor.  
7. To study the characteristics of regulated power supply using Zener diode.  
8. To study the characteristics of regulated power supply by using integrated circuit (IC).  
9. To study the characteristics of phase shift oscillator.  
10. To study the drain and transfer characteristics of junction field effect transistor (JFET).  
11. To study the characteristics of uni-junction transistor.  
12. To study logic gates OR, AND, NOT, NOR and NAND by using DTL and TTL.  
13. To verify NAND and NOR gates are universal gates.  
14. To study the R-S flip-flop.  
15. To study the astable multivibrator by using transistors and find its frequency and duty cycle.

**Text Books**  

**Note:**  
a. Student must perform three periods laboratory work twice a week to complete both Phy 202 and Phy 203.  
b. Practical courses Phy 202 and Phy 203 each will be examined for the duration of
three hours. Students must pass both courses separately.
c. The practical exam will be graded on the basis of the following marking scheme:
Record file 20%
Experiment 60%
Viva 20%

Tribhuvan University
Institute of Science and Technology
Physics Subject Committee
Central Department of Physics

<table>
<thead>
<tr>
<th>Course Title: (Mathematical Physics and Classical Mechanics)</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year: III</td>
<td></td>
</tr>
<tr>
<td>Marks: 100</td>
<td></td>
</tr>
<tr>
<td>Course No.: Phy 301</td>
<td>Pass</td>
</tr>
<tr>
<td>Marks: 35</td>
<td></td>
</tr>
<tr>
<td>Nature of Course: Theory</td>
<td></td>
</tr>
</tbody>
</table>

Course Objectives
At the end of this course the student should be able:
- to acquire sufficient knowledge in mathematical physics and classical mechanics
- to apply this knowledge for higher studies and research in physics

MATHEMATICAL PHYSICS (60%) [96 hours]

Vector analysis: Scalar and vector fields, law of transformation of vectors, polar and axial vectors, solenoidal vectors, rotational and irrotational vectors, vortex lines, Curvilinear coordinates: direction cosines, scale factors, curvature of co-ordinate lines, volume element, rotation of axes, contravariant and covariant vectors, Gradient, divergence, curl and Laplacian in curvilinear co-ordinates, Special orthogonal curvilinear coordinates: cylindrical, spherical, ellipsoidal, hyperbolic and parabolic co-ordinates (20 hrs.)

Tensor analysis: Contravariant, covariant and mixed tensors, Kronecker delta, tensors of rank greater than two, scalars or invariants, tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, stress tensor, Line element and matric tensor, reciprocal tensors, associated tensors, length of a vector, angle between vectors, physical components, Christoffel’s symbols, transformation laws of Christoffel’s symbols, geodesics, covariant derivatives, Tensor form of gradient, divergence, curl and Laplacian (20 hrs.)

Linear vector spaces: Vectors in n-dimensions, linear independence, inner product, Schwartz inequality, representation of vectors and linear operators with respect to a basis, change of basis, Schmidt orthogonalization process, Linear operators and their matrix representation: symmetric,
Hermitian, orthogonal, unitary (normal) matrices, Determination of eigen values and eigen vectors of the matrix, diagonalization (18 hrs.)

**Fourier series and transforms:** Complex Fourier series representation, even and odd functions, Fourier series expansion of square, triangular, saw-tooth waves and output of full wave rectifier, Dirac delta function, Parseval relation, Fourier transform and convolution theorem, Laplace transform, Laplace transform of derivatives and integrals, Use of Fourier and Laplace transform in solving partial differential equations.

(18 hrs.)

**Differential equations:** Series solutions of Bessel’s, Legendre’s, Hermite’s, Laguerre’s differential equations, Rodrigue’s formula, Recurrence relations, associated Legendre and Laguerre polynomials, orthogonality and generating functions (10 hrs.)

**Partial differential equations:** Wave equations, Laplace, Poisson and diffusion equations, boundary value problems, Green’s method of solving partial differential equations. (10 hrs.)

**CLASSICAL MECHANICS (40%) [64 hours]**

**Motion in Central Field:** Motion in central force field, motion in arbitrary potential field, equation of orbits, Kepler’s laws of planetary motion (6 hrs.)

**Elastic and Inelastic Collision:** Collision of particles, collision in laboratory and center of mass systems, cross section, Rutherford scattering (6 hrs.)

**Elementary Principles:** Constraints, Generalized coordinates, generalized displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force and generalized potential, D’Alembert’s principle and Lagrange’s equations (10 hrs.)

**Variational Principles and Lagrange’s Equations:** Calculus of variations: Geodesics, Minimum surface of revolution, The brachistochrone problem, Hamilton’s principle and derivation of Lagrange’s equation, Extension of Hamilton’s principle to nonholonomic systems (Method of Lagrange undetermined multipliers), Conservation theorems and symmetry properties, Energy function and the conservation of energy (12 hrs.)
**Inertial Frames:** Moving co-ordinate system, translating and rotating co-ordinate systems, Coriolis force, Foucault pendulum  
(6 hrs.)

**Motion of Rigid Bodies:** Motion of rigid body, Euler’s theorem, angular momentum and kinetic energy, the inertia tensor, Euler’s equation of motion, torque free motion, Eulerian angle, symmetrical top  
(10 hrs.)

**Relativity:** Galilean invariance, inertial frames of reference, Galilean transformations, non-inertial frames and fictitious forces, Michelson-Morley experiment, Lorentz transformation, length contraction, time dilation, transformation and addition of velocities, variation of mass with velocity, mass energy relation, relation between momentum and energy, transformation of energy and momentum.  
(10 hrs.)

**Text Books:**


7. Herbert Goldstein, Charles Poole and John Safko, Classical Mechanics; Pearson Education


**References:**


Course Objective:
At the end of the practical course the students will be able:

- to relate theoretical concepts to practical skills
- to perform laboratory work and
- to perform major laboratory courses
- to set experiments related to physics
- to design laboratory experiments
- to draw conclusions from laboratory work
- to develop proper laboratory skills
- to interpret laboratory work results

Physics Experiments [180 hrs.]
(A minimum of 20 Experiments must be performed by each student)

1. Estimation of Plank’s constant using photoelectric effect.
2. To determine the linear absorption coefficient of $\gamma$-particles in a matter using a G.M. counter.
3. To use $\gamma$-ray spectrometer to analyze energy of a given radioactive source.
4. To study the $\gamma$-ray spectrum of a radioactive source using a single channel analyzer.
5. To study the phenomenon of Back-Scattering using a thin radioactive source.
6. To study the working of fine beam tube for the determination of the specific charge of an electron.
7. To study the working of CRT (Cathode Ray Tube) for the determination of specific charge of electron.
8. To study Lloyd’s mirror for the determination of wavelength of given source of light.
9. To study the Michelson Interferometer to determine the wavelength of monochromatic light.
10. To study the formation of fringe pattern by wedge shape.
11. To study the phenomenon of hysteresis loss of the material and to determine the hysteresis loss of the material over a cycle.

12. To use the microwave source for studying the phenomenon of (a) Refraction, (b) Interference, (c) Diffraction, and (d) Polarization.

13. To study the specific heat capacity of the materials using Calorimetric method.

14. To find the dielectric constant of a material using resonance method.

15. Determine the resonant frequency and quality factor of parallel LCR circuit.

16. To estimate the current gain ($\beta$) in a Common-Emitter Configuration.

17. To construct Common-Emitter (CE) amplifier and determine the voltage gain of the amplifier with phase relation.

18. To construct Common-Collector (CC) amplifier and determine the voltage gain, input and output impedance with phase relation.

19. To construct Common-Source (CS) amplifier and determine the voltage gain of the amplifier with phase relation.

20. Study the low frequency response circuits and calculate their cut-off frequencies.

21. Study the high frequency response circuits and calculate their cut-off frequencies.

22. Construct the Hartley oscillator and set up it for sinusoidal output waveform of desired frequency.

23. Construct the Colpitt’s oscillator and set up it for sinusoidal output waveform of desired frequency.

24. To construct astablemultivibrator and to study its performance by using 555 timer.

25. To construct monostablemultivibrator and to study its function by using 555 timer.

26. To construct differential amplifier and estimate it’s CMRR (Common mode rejection ratio).

27. Study the characteristic of inverting and non-inverting operational amplifier (Using IC).

28. To study operational amplifier for integrator and differentiator (Using IC).

29. To study the working of half-adder and half-subtractor circuit.

30. Design and constructs the 1-bit digital comparator.

Text Books:

Note:
a. Student must perform three periods laboratory work twice a week to complete practical assignments
b. Practical course Phy302 will be examined for the duration of three hours.
c. The practical exam will be graded on the basis of the following marking scheme:
   - Record file 20%
   - Experiment 50%
   - Error Analysis 10%
   - Viva 20%

Curriculum
FIRSTSEMESTER

Phy501: Mathematical Physics I (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course contains different areas of mathematics that are used extensively in the study of physics.
Objectives:
The objective of this course is to train the students to use the methods of mathematics to formulate and solve problems in physics, and make them capable to apply this knowledge in higher studies and research.
Course Contents:
1. Tensor analysis: 1.1 Law of transformations of vectors, solenoidal vectors, rotational and irrotational vectors, vortex lines 1.2 Application of Vectors 1.3 Special Orthogonal curvilinear coordinates: cylindrical, spherical and ellipsoidal. 1.4 Review of Contravariant, covariant and mixed tensors, Kronecker delta 1.5 Tensors of rank greater than two, scalars or invariants, tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, stress tensor, 1.6 Line element and matric tensor, reciprocal tensors, associated tensors, length of a vector, angle between vectors, physical components, 1.7 Christoffel’s symbols, transformation laws of Christoffel’s symbols, geodesics, covariant derivatives, 1.8 Tensor form of gradient, divergence, curl and Laplacian. [12 hours]
2. Linear vector spaces: 2.1 Vectors in n-dimensions, linear independence, Schwartz inequality, representation of vectors and linear operators with respect to a basis, change of basis, Schmidt orthogonalization process, 2.2 Linear operators and their matrix representation with examples [4 hours]
3. Group Theory: 3.1 Introduction, 3.2 Representation of groups, 3.3 Symmetry and physics 3.4 Discrete and continuous groups 3.5 Symmetric group 3.5 Symmetric group 3.6 Orthogonal groups 3.7 Lie groups 3.8 U(1) and SU(2) groups (introduction only) [8 hours]
4. Review of Integral transforms: 4.1 Fourier transform and convolution theorem, 4.2 Laplace transform: Laplace transform of derivatives and integrals, Derivative of Laplace Transform 4.3 Use of Fourier and Laplace transform in solving partial differential equations. [5 hours]

5. Differential equations: 5.1 Review of Series solutions of Bassels’s, Legendre’s, Hermite’s, Laguerre’s differential equations, 5.2 Associated Legendre and Laguerre polynomials, orthogonality and generating functions. 5.3 Sturm-Liouville’s Theory –Self adjoint operators, Hermitian operators, completeness of eigen functions, Green’s functions-eigenfunction expansion. [10 hours]


TextBooks:

Reference Books:
1. Rajput B.S.– Mathematical Physics, PragatiPrakashan, India (1997)
Phy502: Classical Mechanics (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course contains a description and formulation of classical mechanics.

Objectives:
The objective of this course is to provide the students with knowledge of classical mechanics, and enable them to apply the knowledge for solving various problems in related topics, and also for higher studies and research.

Course Contents:

2. Variational principles and Lagrange’s equations: 2.1. Calculus of variations: Geodesics, Minimum surface of revolution, Thebrachistochrone problem, 2.2. Hamilton’s principle and derivation of Lagrange’s equation, 2.3. Extension of Hamilton’s principle to nonholonomic systems (Method of Lagrange undetermined multipliers), 2.4. Conservation theorems and symmetry properties, 2.5. Energy function and the conservation of energy[7 hours]

3. The Central Force Problem: 3.1. Reduction to the equivalent one-body problem, 3.2 The equations of motion and first integrals, 3.3 The equivalent one-dimensional problem, and classification of orbits, 3.4 The Virial theorem, 3.5 The differential equation for the orbit, and integrable power-law potentials, 3.6 Conditions for closed orbits (Bertrand’s theorem), 3.7 The Kepler’s problem: Inverse-square law of forces, 3.8 The motion in time in the Kepler’s problem, 3.9 The Laplace-Runge-Lenz vector, 3.10 Scattering in a central force field, 3.11 Transformation of the scattering problem to laboratory coordinates[10 hours]

4. Oscillations: 4.1. Formulation of the problem, 4.2. The eigenvalue equation and the principal axis transformation, 4.3. Free vibrations of a linear triatomic molecule[3 hours]

5. The Hamilton equations of motion: 5.1. Legendre transformations and the Hamilton equations of motion, 5.2. Cyclic coordinates and conservation theorems, 5.3. Derivation of Hamilton’s
equations from variational principle, 5.4. The principle of least action[4 hours]

6. Canonical transformations: 6.1. The equations of canonical transformation, 6.2. The symplectic approach to canonical transformation, 6.3 Poisson brackets and other canonical invariants, 6.4. Equations of motion, Infinitesimal canonical transformations, and Conservation theorems in the Poisson bracket formulation, 6.5 The angular momentum Poisson bracket relations, 6.6. Symmetry groups of mechanical systems[7 hours]

7. Hamilton-Jacobi theory and action-angle variables: 7.1. The Hamilton-Jacobi equation for Hamilton’s principal function, 7.2. The Hamilton-Jacobi equation for Hamilton’s characteristic function, 7.3. Separation of variables in the Hamilton-Jacobi equation, 7.4. Action-angle variables, 7.5. The Kepler problem in action-angle variables[6 hours]

8. Introduction to the Lagrangian and Hamiltonian formulations for continuous systems and fields: 8.1. The transition from a discrete to a continuous system, 8.2. The Lagrangian formulation for continuous systems, 8.4 Quantization of electromagnetic field 8.3. Hamiltonian formulation[4 hours]

Textbooks:

Referencebooks:
Phy503: Quantum Mechanics I (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course develops the formulation of quantum mechanics and its applications in various areas.

Objectives:
The objective of this course is to provide the students with adequate knowledge of non-relativistic quantum mechanics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:
1. Formulation of Quantum Theory: 1.1 Development of Quantum Theory: Copenhagen Interpretation 1.2 Review of de Broglie’s relations, wavefunctions and Schrodinger equation and Uncertainty principle.[3 hours]

2. Mathematical Tools of Quantum Mechanics: 2.1 One particle wave function space: vector space, scalar product, linear operator, closure relation, discrete and continuous bases 2.2 State space, Dirac notation: ket and bra vectors, dual space, correspondence between ket and bra, projection operator, Hermitian conjugation 2.3 Representation in state space: orthonormalization relation, closure relation, matrix representations of kets, Bras, operators, change of representations 2.4 Eigenvalue equations, observables: definition of an observable, the projectors, sets of commuting observables, complete sets of commuting observables.[10 hours]

3. Postulates of Quantum Mechanics: 3.1 Introduction 3.2 Statement of the postulates 3.3 Physical interpretation 3.4 Physical implications of the Schrodinger equation: superposition principle, conservation of probability, equation of motion for an observable, principle of first quantization, Ehrenfest theorem.[7 hours]

4. One Dimensional Barriers: 4.1 Free particle, 4.2 Concept of potential, 4.3 Potential barrier, 4.4 Ramsauer Townsend effect, 4.5 Smooth barrier, 4.6 Cold emission of electrons in a metal, 4.7 Alpha decay, 4.8 Virtual binding.[6 hours]

5. Bound States in one Dimension: 5.1 Bound states, 5.2 Parity, 5.3 Potential with finite walls, 5.4 Box normalization, 5.5 Double well model of a molecule, 5.6 Kronig-Penny model for metals, 5.7 Linear harmonic oscillator, 5.8 Creation operators, momentum representation for
oscillators. 5.9 Two coupled harmonic oscillators.[8 hours]

6. Motion in Three Dimensions: 6.1 Integrals of motion, 6.2 Particle in a centrally symmetric field, 6.3 Angular solutions, 6.4 Orbital angular momentum, 6.5 Properties of spherical harmonics.[6 hours]

7. Central Potential Problems: 7.1 Two interacting particles, 7.2 Rigid rotator, 7.3 Free particle radial function, 7.4 Particle in a spherical box, 7.5 Spherical potential well of finite depth, 7.7 Isotropic harmonic oscillator, 7.8 General results for two particles bound states.[7 hours]

Text

Books:

Reference

Books:
Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course further develops on the theory and applications of electronics.

Objectives:
The course will give an understanding of the formulation of the theory of electronics, so that the students will be able to apply the knowledge in different situations, and also in higher studies and research.

Course Contents:

Analog Electronics: Circuit Theory:
1(a) Network Transformation: 1.1 Network definition, Mesh and node circuit analysis, Principle of duality, 1.2 Reduction of complicated network, Conversions between T and π sections, 1.3 The superposition theorem, The reciprocity theorem, 1.4 Brief revision of Thevinin’s, Norton’s Theorem and The maximum power-transfer theorem, 1.5 A.C. bridge (Lattice network), Sensitivity in bridge measurements. [5 hours]
(b) Resonance: 1.6 Definition of Q, Series resonance and Band width of the series resonant circuit, 1.7 Parallel resonance circuit or anti-resonance, Condition for maximum impedance and impedance variation with frequency, 1.8 Band width of anti-resonant circuits, The general case-resistance present in both branches and anti-resonance at all frequencies.[3 hours]

Semiconductor Circuit Response and Design:
2(a) Integrated, Differential and Operational Amplifier Circuits: 2.1 Overview of CE, CC, CB and CS amplifiers, 2.2 Introduction of an ideal differential amplifier (BJT and FET), Common mode parameters, 2.3 Practical differential amplifiers, Introduction to operational amplifiers.[3 hours]
(b) Operational Amplifier Theory: 2.4 The ideal operational amplifier, 2.5 Slew rate, Offset current and voltages. [2 hours]
(c) Application of Operational Amplifiers: 2.6 Controlled voltage and current sources, 2.7
Integration, Differentiation and Wave-shaping, 2.8 Oscillators: The Barkhausen criterion, RC phase shift, Wein-bridge and Crystal, 2.9 Concept of active filters and its design, 2.10 Introduction of Clipping, Clamping and Rectifying circuits.

3(a) Frequency response: 3.1 Definition and basic concepts, Decibel and logarithmic plots, Series capacitance and low frequency response, 3.2 Shunt capacitance and high frequency response, Transient response, Low and high frequency response of BJT and FET amplifiers.

(b) Power Supply and Voltage Regulators: 3.3 Introduction, Rectifiers and different types of filters, 3.4 Voltage multipliers, 3.5 Voltage regulation: Series and shunt voltage regulators, Switching regulators, 3.7 Different types of Integrated circuit regulator (Three-terminal type and adjusted type).

Digital Electronics:

4(a) Digital Circuit Analysis and Design: 4.1 Introduction, Boolean laws and theorem, 4.2 Sum of Products methods and Product of Sum methods, Truth table to Karnaugh map, Pairs, quads and octets, 4.3 Karnaugh’s simplifications.

(b) Data Processing Circuits: 4.4 Multiplexers, De-multiplexers, 4.5 Decoder, BCD to decimal decoders and Seven segment decoders, 4.6 Encoders, Decimal to BCD encoder, 4.7 Exclusive-OR gates, Parity generators-checkers.

5(a) Arithmetic Circuits: 5.1 Review of binary addition and subtraction, Unsigned binary numbers, Sign-magnitude numbers, 2’s compliment representation and its arithmetic, 5.2 Arithmetic building blocks, 5.3 The adder and subtracter, Binary multiplication and division.

(b) TTL Circuits: 5.5 Digital integrated circuits, 7400 Devices: Two-input TTL NAND gate, 5.6 TTL Parameters, AND-OR-INVERT gates, 5.7 Three-state TTL devices, Positive and negative logic.

(c) Clock and Timers: 5.9 Clock Waveforms, Review of RS Flip-Flop, 5.10 Internal structure of 555 timer, 5.11 555 Timer-Astable and Mono-stable.


(b) Shift Registers: 6.4 Types of registers (Serial in - Serial out, Serial in - Parallel out, Parallel in - Serial out, Parallel in - Parallel out), 6.5 Ring counters.

(c) Counters: 6.6 Asynchronous counters, Decoding gates, 6.7 Synchronous counters, Shift Counters.

Text Books:
1. Ryder, J.D. – Network, Lines and Fields, Prentice Hall of India (1955)

Reference Books:

Phy505: Physics Practical I (Compulsory) (Lab180, T45, 3CH)

Nature of the course: Practical / Full Marks: 50 / Pass Marks: 25

Course Description:

Practical course consists of four sections: (a) General Experiments, (b) Optical Experiments, (c) Nuclear Experiments and (d) Electronics Experiments. In the M.Sc. physics first semester, students have to perform 16-20 experiments in 180 working hours in order to fulfill 3 CH. Students are required to perform 3 hours laboratory work each day. In addition, there will be 45 hours computation class in order to learn the method of data analysis using suitable software. They have to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed. Students are required to perform at least 15 experiments from the list (given below).

Course Objectives:

1. To provide students with skill and knowledge in the experimental methods.
2. To make them able to apply knowledge to practical applications.
3. To make them capable of presenting their results/conclusions in a logical order.

Course Contents:

1. To study the Fresnel biprism for the determination of the wavelength of a given monochromatic light and thickness of mica sheet.
2. To study Lloyd’s mirror for the determination of wavelength of Hg light.
3. To study the formation of fringe pattern by wedge shape.
4. To study the variation of refractive index with concentration of sugar solutions using a hollow prism.
5. To design and study the series and parallel LCR circuits for finding the quality factor of the elements.
6. To study the absorption of β-particle by material to estimate the end-point energy of the β-particle.
7. To study the absorption of γ-ray by the material of lead to determine its linear absorption coefficient, $\mu$. 
8. To study the level of natural background radiation at the laboratory in the given condition
9. To construct regulated power supply unit.
10. To construct CE amplifier for the determination of the voltage gain of the amplifier.
11. To construct CC amplifier for estimating input and output impedance.
12. Use Zener diode to construct a variable regulated power supply.
13. To construct astable multivibrator using 555 timer and study its performance.
14. To construct monostable multivibrator using 555 timer and study its function.
15. To construct and to study the characteristics of RS flip-flop and J-K flip-flop.
16. To construct a voltage multipliers (doubler and tripler) and study its characteristics.
17. To construct and study the working of NOT, AND, OR gates using diodes and transistors.
Also calculate the power loss in transistors in each case wherever it is applicable.
18. Solve the given equation using K-map and construct the circuit with verification

SECOND SEMESTER

Phy551: Mathematical Physics II (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course contains different areas of mathematics that are used extensively in the study of physics.

Objectives:
The objective of this course is to train the students to use the methods of mathematics to formulate and solve problems in physics, and make them capable to apply this knowledge in higher studies and research.

Course Contents:
1. Complex variable: 1.1 Functions of a complex variable, single and multi valued functions, Riemann sheets 1.2 Analytic functions and Cauchy – Riemann conditions, 1.3 Analytic continuation 1.4 Cauchy integral theorem and formula, 1.5 Taylor and Laurent expansions of functions of a complex variable, 1.6 Residue theorem and applications, 1.7 Conformal transformations 1.8 Dispersion relation.[15 hours]

2. Numerical analysis (use of computer is optional): 2.1 Interpolation and extrapolation: approximation of given data by a polynomial, interpolation and extrapolation of data, 2.2 Solution of equation: polynomial equation, determination of roots, 2.3 Numerical integration: trapezoidal, Simpson and Romberg method, 2.4 Matrices: eigen values and eogen vectors, inverse of square matrix by Gauss-Jordan elimination method, 2.5 Differential equation: solution of differential equation by Runge-Kutta method.[14 hours]

3. Statistics: 3.1 Review of Data handling: histogram, mean, mode, median and standard deviation, moments, skewness, Kurtosis, 3.2 Distribution functions: bionomial, normal and Poisson distributions, 3.3 Curve fitting: least square fit for straight lines and
curves, 3.4 Chi-square tests: observed and theoretical frequencies, significance tests, goodness of fit, central limit theorem, 3.5 Error analysis.[10 hours]

4. Differential Geometry: 4.1 Introduction - Application of differential geometry in physics 4.2 differentiable manifolds 4.3 Tangent and co-tangent space 4.4 Vector fields.[6 hours]

Text

Books:


Reference Books:

1. Rajput B.S. – Mathematical Physics, PragatiPrakashan, India (1997)

Phy 552: Statistical Mechanics (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course contains a description and formulation of statistical mechanics.

Objectives:
The objective of this course is to provide the students with knowledge of statistical mechanics, and enable them to apply the knowledge for solving various problems in related topics, and also for higher studies and research.

Course Contents:

1. Classical statistical mechanics: 1.1 Review of Thermodynamics 1.2 The statistical basis of thermodynamics 1.3 Review of classical mechanics – Hamiltonian equation of motion 1.4 Macroscopic and microscopic states, 1.5 Phase space, 1.6 Liouville’s theorem 1.7 Postulate of statistical mechanics 1.8 Microcanonical ensemble 1.9 Derivation of thermodynamic properties 1.10 Classical ideal gas 1.12 Gibb’s paradox 1.13 Classical harmonic oscillators in Microcanonical Ensemble 1.13 Canonical ensemble 1.14 Partition function 1.15 Energy fluctuation in canonical ensemble 1.16 Grand Canonical ensemble 1.17 Classical ideal gas in canonical and grand canonical ensemble 1.18 Classical harmonic oscillators in Canonical Ensemble 1.19 Equivalence of various ensembles, 1.20 Thermodynamics of magnetic systems: negative temperature 1.21 Generalized equipartition theorem – theorem of equipartition of energy and virial theorem 1.22 Virial Theorem -equation of state for classical interacting particles. [18 hours]

2. Quantum statistical mechanics: 2.1 Postulates of quantum statistical mechanics 2.2 Density matrix and its properties 2.3 Ensembles in quantum statistical mechanics – microcanonical, canonical, and grand canonical ensembles 2.4 Partition functions with examples including (I) an electron in magnetic field (II) a free particle in a box (III) a linear harmonic oscillator 2.5 Third law of thermodynamics 2.6 Symmetric and antisymmetric wave functions 2.7 The ideal gases: Microcanonical ensemble 2.8 The ideal gases: grandcanonical ensemble 2.9 Grand partition function 2.10 Occupation number 2.11 Partition functions for diatomic molecule.[12 hours]

3. Application of Ideal Bose and Fermi systems: 3.1 Thermodynamical behavior of ideal Bose gas, 3.2 Photons –Black body radiation and Planck’s law of radiation, 3.3 Thermodynamics of weakly degenerate Bose gas, 3.4 Thermodynamics of strongly degenerate Bose gas – Bose-
Einstein condensation and liquid helium
3.5 Phonons in solids, specific heat of solids
3.6 Thermodynamical behavior of ideal Fermi gas – weakly and strongly degenerate Fermi gas,
3.7 Free electron in metals, 3.8 Statistical equilibrium of white dwarf and neutron stars.[10 hours]

4. Phase Transitions: 4.1 Condensation of van der Waals gas 4.2 A dynamical model of phase
transitions, 4.3 Ising model.[5 hours]

Text books:

Reference books:
2. A. McQuarrie - Statistical Mechanics, Harper and Row, New York (1973)
   York (1965)
Phy553: Solid State Physics (45L, 15T, 3CH)
Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course develops the basic formulation of solid state physics and its applications in various areas.

Objectives:
The objective of this course is to provide the students with adequate knowledge of solid state physics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:
1. Crystal Structure: 1.1 Translation symmetry - periodic array of atoms 1.2 Simple lattice, 1.3 Index systems for crystal planes 1.4 Review of Simple crystal structures: NaCl, CsCl, hexagonal closed packed, diamond and cubic zinc sulfide structure 1.5 Reciprocal lattice, Brillouin zone, 1.6 Crystal diffraction, 1.7 Structure factor, 1.8 Crystal binding: a) Van der waal’s crystals, b) ionic crystals, c) Metals, d) Covalent crystals, e) Hydrogen bonded crystals, 1.7 Elastic constants and their determination.[9 hours]

2. Lattice Vibration: 2.1 Vibration of crystals with monoatomic basis, 2.2 Vibration of crystals with two atoms per primitive basis, 2.3 Quantization of elastic waves, 2.4 Phonon momentum, 2.5 Inelastic scattering by phonon, 2.6 Thermal properties of solid: density of states in one, two and three dimensions, 2.7 Phonon heat capacity: Review of Debye and Einstein’s model, 2.8 Thermal Conductivity 2.9 Anharmonic crystal interaction: Thermal expansion.[7 hours]

3. Electrons in bands: 3.1 Review of Nearly free electron model, Bloch theorem, Kronig-Penny model, 3.2 Wave equation of electron in periodic potential, 3.3 Number of orbitals in a band, 3.4 Calculation of energy Bands: Tight binding approximation, Wigner Seitz method, cohesive energy, pseudopotential methods 3.5 Fermi surface: Construction of Fermi surfaces – nearly free electrons, Electron orbits, hole orbits and open orbits 3.6 Experimental methods in Fermi surface studies: quantization of orbits in a magnetic field, de Haas-van Alphen effect, Fermi surface of copper and gold.[13 hours]

4. Semiconductor: 4.1 Band diagram of semiconductor, 4.2 Intrinsic carrier concentration, 4.3 Impurity conductivity: thermal ionization of donors and acceptors.[3 hours]
5. Dielectric properties: 5.1 Dielectric constant and polarizability, 5.2 Electronic, ionic and orientational polarizabilities, 5.3 Complex dielectric constant 5.4 Dielectric losses and relaxation time. [4 hours]

6. Magnetism: 6.1 Diamagnetism and paramagnetism, 6.2 Quantum theory of diamagnetism of mononuclear systems, 6.3 Quantum theory of paramagnetism, Hund rules 6.4 Magnetic ordering, 6.5 Ferromagnetic order: Curie point and exchange integral, Temperature dependence of the saturation magnetization, ferromagnetic domains, Bloch wall, Saturation Magnetization at Absolute zero, 6.6 Magnons, thermal excitation of magnons, 6.6 Ferrimagnetic order: Curie temperature and susceptibility 6.7 Antiferrimagnet, susceptibility below Neel temperature. [9 hours]

Text books:


References:


Phy504: Electrodynamics I (45L, 15T, 3CH)

Nature of the course: Theory / Full Marks: 50 / Pass Marks: 25

Course Description:
This course further develops on the theory and applications of electrodynamics.

Objectives:
The course will give an understanding of the formulation of the theory of electrodynamics, so that the students will be able to apply the knowledge in different situations, and also in higher studies and research.

Course Contents:
1. Introduction to Electrostatics: 1.1 Review of the Electrostatic Field and Electrostatic Potential 1.2 Poisson and Laplace equations 1.3 Green’s theorem 1.4 Uniqueness of the solution with Dirichlet or Neumann boundary conditions 1.5 Formal solution of electrostatic boundary-value problem with Green Function [4 hours]

2. Boundary Value Problems in Electrostatics: 2.1 Methods of image 2.2 Point charge in the presence of a (a) grounded conducting sphere (b) Charged insulated conducting sphere 2.3 Conducting sphere in a uniform electric field by method of image 2.4 Green function for the sphere and general solution for the potential 2.5 Conducting sphere with hemisphere at different potentials 2.6 Laplace equation in spherical coordinates and boundary value problems with azimuthal symmetry 2.7 Associated Legendre functions and the spherical harmonics $Y_{lm}$, Use of addition theorem for spherical harmonics 2.8 Expansion of Green function in spherical coordinates [10 hours]

3. Multipoles, Electrostatics of Macroscopic Media, Dielectrics: 3.1 Multipole expansion 3.2 Multipole expansion of the energy of a charge distribution in an external field 3.3 Elementary treatment of electrostatics with ponderable media 3.4 Boundary value problem with dielectrics 3.5 Electrostatic energy in dielectric media [6 hours]

4. Magnetostatics: 4.1 Review of Magnetostatics (Biot and Savart law, Ampere’s law, Vector potential) 4.2 Magnetic fields of a localized current distribution, magnetic moment 4.3 Force and torque on the energy of a localized current distribution in an external magnetic induction, 4.4 Macroscopic equations, Boundary conditions on $B$ and $H$, 4.5 Method of solving boundary value problems in magnetostatics 4.6 Uniformly magnetized sphere 4.7 Magnetized sphere in an external field, permanent magnets 4.8 Faraday’s law of induction 4.9 Energy in the magnetic
5. Maxwell’s Equations: 5.1 Maxwell’s equations 5.2 Vector and scalar potentials 5.3 Gauge Transformations, Lorenz Gauge, Coulomb Gauge 5.4 Green functions for the wave equation 5.5 Poynting’s theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields 5.6. Poynting's Theorem in Linear Dispersive Media with Losses.[7 hours]

6. Electromagnetic Waves and Wave Propagation: 6.1 Plane waves in nonconducting medium 6.2 Linear and circular polarization; Stokes Parameters 6.3 Reflection and Refraction of electromagnetic waves at a plane interface between dielectrics 6.4 Polarization by Reflection and Total Internal Reflection 6.5 Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas 6.6 Simplified Model of Propagation in the Ionosphere and Magnetosphere. [7 hours]

7. Waveguides, Resonant Cavities: 7.1 Fields at the surface of and within a conductor 7.2 Cylindrical cavities and waveguides 7.3 Waveguides 7.4 Modes in a rectangular waveguide.[3 hours]

Text Books:

Reference Books:


Phy555: Physics Practical II (Compulsory) (Lab180, T45, 3CH)

Nature of the course: Practical / Full Marks: 50 / Pass Marks: 25

Course Description:

Practical course consists of four sections: (a) General Experiments, (b) Optical Experiments, (c) Nuclear Experiments and (d) Electronics Experiments. In addition, there is a computation laboratory in order to learn computational/numerical technique. In the M.Sc. physics second semester, students have to perform 15 experiments in 180 working hours in order to fulfill 3 CH. Students are required to perform 3 hours laboratory work each day. In addition, there will be 45 hours computation classes in order to learn the method of data analysis using suitable software. They have to write a laboratory report on each experiment they perform and get them duly checked and signed by the concerned teacher. They should write their reports in a separate sheet, and to keep them neat and properly filed. Students are required to perform at least 14 experiments from the list (given below).

Course Objectives:
1. To provide students with skill and knowledge in the experimental methods.
2. To make them able to apply knowledge to practical applications.
3. To make them capable of presenting their results/conclusions in a logical order.

Course Contents:
1. To determine the half life of the given radioactive source. (nuclear lab)
2. To study the phenomenon of Back-Scattering using a thin radioactive source. (nuclear lab)
3. To study the phenomenon of hysteresis loss of the material and to determine the hysteresis loss of the material over a cycle. (general lab)
4. To study the Lissajous pattern for the determination of the frequency of a given unknown source. (general lab)
5. To study the current–voltage characteristics of a photocell and hence use photoelectric method to determine the value of Plank’s constant. (optical lab)
6. To study the specific heat capacity of the materials using Calorimetric method. (general lab)
7. To study the temperature dependence of resistance of a given semiconductor. (general lab)
8. To study differential amplifier and estimate it’s CMRR.(electronics lab)
9. To construct and to study the Exclusive-OR and Exclusive-NOR gates by using universal gates. (electronics lab)
10. To study operational amplifier for its input-output waveform and use it as an integrator and
M.Sc. Old, Course

Introduction:

Master level physics syllabus has been revised and updated. The new courses have been designed keeping in view with recent developments in physics. Availability of additional specialties in new areas and upgraded quality of the courses will meet the requirement of prospective students. Various elective courses are incorporated in the syllabus and some of the old courses are thoroughly revised.

Objectives:

The courses are designed with the following objectives:

1. To give students up to date knowledge of recent trends in physics.
2. To impart skills to the students in the areas of theoretical, experimental and applied physics.
3. To develop manpower in teaching physics at the tertiary level and to conduct research in physics.
4. To produce high level research manpower in physics.

Eligibility for Admission: The candidates who have passed B.Sc. degree with major in physics from Tribhuvan University or equivalent degree with the same major from a university recognized by Tribhuvan University shall be considered eligible to apply for admission to M.Sc. degree course.
**Admission Criteria:** An applicant seeking admission to M.Sc. physics must appear in an entrance examination conducted by the Central Department of Physics/Campus. The applicant who fails to appear in the entrance examination or to obtain a minimum qualifying score will not be given admission. Admission of the students will be based strictly on the merit list and on the enrollment capacity of the Central Department of Physics/Campus.

**Course Structure:** There will be altogether ten courses, five in each academic year carrying full marks of 100 each. In each theory course, the minimum number of period per week is four and duration of a period is one hour. In the first year, all five papers are compulsory and in the second year, there will be three compulsory papers including practical/project work and two elective papers. A student can choose any two papers from the electives including dissertation. There will be an option between one of the elective courses and the dissertation. The practical course in the second year is divided into two parts namely general and project work. For the project work, one can either choose project work (theoretical or practical) or perform electronics experiments. However, one student cannot choose dissertation and project work both. For practical class, a student has to work five days a week working four hours a day.

**First Year**

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course title</th>
<th>Full Mark</th>
<th>Pass Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy 511</td>
<td>Mathematical Physics</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 512</td>
<td>Classical and Statistical Mechanics</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 513</td>
<td>Quantum Theory and Spectroscopy</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 514</td>
<td>Electromagnetism and Electronics</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 515(A&amp;B)</td>
<td>Practical (General and Electronics)</td>
<td>(50+50)</td>
<td>(20+20)</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Compulsory Courses</th>
<th>Full Mark</th>
<th>Pass Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy 621</td>
<td>Quantum Mechanics and Electrodynamics</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 622</td>
<td>Physics of Nuclei, Particles and Solids</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 623</td>
<td>a) General physics practical</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>b) Project work/Electronics practical</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Elective courses (Any Two)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Including dissertation</strong></td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Phy 624</td>
<td>Solid State Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 625</td>
<td>Condensed Matter Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 626</td>
<td>Microelectronics and Optoelectronics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 627</td>
<td>Physics of Liquid State, Liquid Crystals and Polymers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 628</td>
<td>Seismology (Geophysics)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 629</td>
<td>Atmospheric Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 630</td>
<td>Plasma Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 631</td>
<td>Biomedical Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 632</td>
<td>Gravitation and Cosmology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phy 650</td>
<td>Dissertation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** An elective course will be offered subject to the concurrence of the Department. The physics subject committee may also develop new elective courses in future.

**Course Duration:**

The entire course is spread over two academic years. There is a separate annual examination after the end of each academic year.

**Hours of Instruction:**

a) Working days: 150 days in an academic year.

b) Class hour:

i) Theory: One theory paper of 100 marks will have 4 hours of lecture per week.

   ii) Practical: One practical paper of 100 marks will have 20 hours of Practical per week.

c) Attendance: 70 percent attendance in the class is required.

**Examination:**

The examination in each course will be a written examination carrying 100 full mark and of 4 hours duration. It is envisaged that at least each unit of the syllabus appears in the question. There will be a choice in the question from within the unit and choice of around 32% will be given in each paper. The practical examination will be of 6 hours duration.

**Evaluation:**
Institute of Science and Technology, Tribhuvan University will conduct annual examinations. The students will have to pass each course at each level separately. The minimum pass marks is 40 percent both for theory and practical.

A student having passed his/her two years of study will be graded as below on the basis of the average marks received in the two years:

- 75 percent and above Distinction
- 60 percent and above First Division
- 50 percent and above Second Division
- 40 percent and above Third Division
Paper I

Mathematical Physics

Course No.: Phy 511  
Full Marks: 100

Nature of the course: Theory  
Pass Marks: 40

Year : I

Course Description:

This course contains different areas of mathematics that are used extensively in the study of physics.

Objectives:

The objective of this course is to train the students to use the methods of mathematics to formulate and solve problems in physics, and make them capable to apply this knowledge in higher studies and research.

Course Contents:

1. **Vector Analysis:** 1.1 Scalar and vector fields, law of transformation of vectors, polar and axial vectors, solenoidal vectors, rotational and irrotational vectors, vortex lines, 1.2 Curvilinear co-ordinates: direction cosines, scale factors, curvature of co-ordinate lines, volume element, rotation of axes, contravariant and covariant vectors, 1.3 Gradient, divergence, curl, and Laplacian in curvilinear co-ordinates, 1.4 Special orthogonal curvilinear co-ordinates: cylindrical, spherical, ellipsoidal, hyperbolic and parabolic co-ordinates.

2. **Tensor Analysis:** 2.1 Contravariant, covariant and mixed tensors, Kronecker delta, tensors of rank greater than two, scalars or invariants, tensor fields, symmetric and skew symmetric tensors, fundamental operations with tensors, stress tensor, 2.2 Line element and matrix tensor, reciprocal tensors, associated tensors, length of a vector, angle between vectors, physical components, 2.3 Christoffel’ symbols, transformation laws of Christoffel’s symbols, geodesics, covariant derivatives, 2.4 Tensor form of gradient, divergence, curl and Laplacian.
3. **Linear Vector Spaces:** 3.1 Vectors in n-dimensions, linear independence, inner product, Schwarz inequality, representation of vectors and linear operators with respect to a basis, change of basis, Schmidt orthogonalization process, 3.2 Linear operators and their matrix representation: symmetric, Hermitian, orthogonal, unitary (normal) matrices, 3.3 Determination of eigen values and eigen vectors of the matrix, diagonalization.

4. **Fourier Series and Transforms:** 4.1 Complex Fourier series representation, even and odd functions, Fourier series expansion of square, triangular, saw-tooth waves and output of full wave rectifier, Dirac delta function, Parseval relation, 4.2 Fourier transform and convolution theorem, 4.3 Laplace transform, Laplace transform of derivatives and integrals, 4.4 Use of Fourier and Laplace transform in solving partial differential equations.

5. **Differential Equations:** 5.1 Series solutions of Bessel’s, Legendre’s, Hermite’s Laguerre’s differential equations, Rodrigues formula, Recurrence relations, associated Legendre and Laguerre polynomials, orthogonality and generating functions.


7. **Complex Variable:** 7.1 Functions of a complex variable, single and multi valued functions, Riemann sheets, 7.2 Analytic functions and Cauchy – Riemann conditions, 7.3 Cauchy integral theorem and formula, 7.4 Taylor and Laurent expansions of functions of a complex variable, 7.5 Residue theorem and applications, 7.6 Conformal transformations.

8. **Numerical Analysis:** 8.1 Interpolation and extrapolation: approximation of given data by a polynomial, interpolation and extrapolation of data, 8.2 Solution of equation: Polynomial equation, determination of roots, 8.3 Numerical integration: trapezoidal, Simpson and Romberg method, 8.4 Matrices: eigen values and eigen vectors, inverse of square matrix by Gauss-Jordan elimination method, 8.5 Differential equation: solution of different equation by Runge-Kutta method.

9. **Statistics:** 9.1 Probability: definition, conditional probability, dependent and independent events, probability distributions, 9.2 Data handling: histogram, mean, mode, meridian and standard deviation, moments, skewness, Kurtosis, 9.3 Distribution functions: binomial, normal and Poisson distributions, 9.4 Curve fitting: least square fit for straight lines and curves, 9.5 Chi-square tests: observed and theoretical frequencies, significance tests, goodness of fit, central limit theorem, 9.6 Error analysis.

**Text Books:**


**Reference Books:**

Course No.: Phy 512
Full Marks: 100
Nature of the course: Theory
Pass Marks: 40
Year : I

Course Description:
This course contains a description and formulation of classical and statistical mechanics.

Objectives:
The objective of this course is to provide the students with knowledge of classical and statistical mechanics, and enable them to apply the knowledge for solving various problems in related topics, and also for higher studies and research.

Course Contents:

1. Constrained Motion and Constraints: 1.1 Constraints, 1.2 Generalized coordinates, generalized displacement, generalized velocity, generalized acceleration, generalized momentum, generalized force and generalized potential, 1.3 D’Alembert’s principle and Lagrange’s equations

2. Variational Principles and Lagrange’s Equations: 2.1 Calculus of variations: Geodesics, Minimum surface of revolution, The brachistochrone problem, 2.2 Hamilton’s principle and derivation of Lagrange’s equation, 2.3 Extension of Hamilton’s principle to nonholonomic systems (Method of Lagrange undetermined multipliers), 2.4 Conservation theorems and symmetry properties, 2.5 Energy function and the conservation of energy

3. Rigid Body: 3.1 The independent coordinates of a rigid body, 3.2 The Euler angles, 3.3 Euler’s theorem on the motion of a rigid body, 3.4 Finite rotations and infinitesimals rotations, 3.5 Rate of change of a vector, 3.6 The Coriolis effect, 3.7 Angular momentum and kinetic energy of motion about a point, 3.8 The inertia tensor and the moment of inertia, 3.9 The heavy symmetrical top with one point fixed
4. Oscillations: 4.1 Formulation of the problem, 4.2 The eigenvalue equation and the principal axis transformation, 4.3 Free vibrations of a linear triatomic molecule

5. The Hamilton Equations of Motion: 5.1 Legendre transformations and the Hamilton equations of motion, 5.2 Cyclic coordinates and conservation theorems, 5.3 Derivation of Hamilton’s equations from variational principle, 5.4 The principle of least action

6. Canonical Transformations: 6.1 The equations of canonical transformation, 6.2 Poisson brackets and other canonical invariants, 6.3 Equations of motion, 6.4 Infinitesimal canonical transformations, 6.5 The angular momentum Poisson bracket relations, 6.6 Liouville’s theorem

7. Hamilton-Jacobi Theory and action-angle Variables: 7.1 The Hamilton-Jacobi equation for Hamilton’s principle function, 7.2 The Hamilton-Jacobi equation for Hamilton’s characteristics function, 7.3 Separation of variables in the Hamilton-Jacobi equation, 7.4 Action-angle variables, 7.5 The Kepler problem in action-angle variables

8. Introduction to Continuous Systems and Fields: 8.1 The transition from a discrete to a continuous system, 8.2 The Lagrangian formulation for continuous systems, 8.3 Hamiltonian formulation


10. Quantum Statistical Mechanics: 10.1 Postulates of quantum statistical mechanics, 10.2 Density matrix and its properties, 10.3 Ensembles in quantum statistical mechanics-microcanonical, canonical, and grand canonical ensembles, 10.4 Partition functions with examples including (I) an electron in magnetic field (II) a free particle in
a box (III) a linear harmonic oscillator, 10.5 Third law of thermodynamics, 10.6 Symmetric and antisymmetric wave functions, 10.7 The ideal gases: Microcanonical ensemble, 10.8 The ideal gases: grand canonical ensemble, 10.9 Grand partition function, 10.10 Occupation number, 10.11 Partition functions for diatomic molecule


Text Books:


Reference Books:


Paper III

Quantum Theory and Spectroscopy
Course No.: Phy 513

Nature of the course: Theory

Year : I

Course Description:

This course further develops the formulation of quantum mechanics and spectroscopy for applications in various areas.

Objectives:

The objective of this course is to provide the students with adequate knowledge of non-relativistic quantum mechanics and enable them to apply the knowledge to study the atomic, molecular and other mechanical systems.

Course Contents:

1. **Introduction to Quantum Theory**: 1.1 History, Schrodinger equation, superposition, 1.2 Uncertainty principle, simple problems.

2. **Postulates of Quantum Mechanics**: 2.1 Probability density, probability amplitude, operators, expectation values, 2.2 Conservation of total probability, probability current, equation of motion, principle of superposition, Dirac notation, orthogonality of eigenfunctions, expansion in terms of eigenfunctions (discrete spectrum), continuous spectrum, simultaneously measurable quantities, uncertainty relation, 2.3 Linear operators, matrix element, integral form of time independent Schrodinger equation, Hilbert space.

3. **One Dimensional Barriers**: 3.1 Free particle, 3.2 The concept of potential, 3.3 Boundary condition, 3.4 Potential step, 3.5 Potential barrier, 3.6 Ramsauer Townsend effect, 3.7 Smooth barrier, 3.8 Cold emission of electrons in a metal, 3.9 Alpha decay, 3.10 Virtual binding.

4. **Bound States in One Dimension**: 4.1 Bound states, 4.2 Potential box, parity, 4.3 Potential with finite walls, 4.4 Box normalization, 4.5 Double well model of a molecule, 4.6 Kronig-Penny model for metals, 4.7 Linear harmonic oscillator, 4.8 Creation operators, momentum representation for oscillators, 4.9 Coherent quasi classical states of oscillator, 4.10 Two coupled harmonic oscillators, 4.11 Infinite Linear chain of coupled oscillators (phonons).
5. **Motion in Three Dimensions:** 5.1 Integrals of motion, 5.2 Special functions of eigenvalue problem, 5.3 Particle in a centrally symmetric field, 5.4 Angular solutions, 5.5 Radial equation, 5.6 Orbital angular momentum, 5.7 Total angular momentum: general properties of spherical harmonics.

6. **Central Potential Problems:** 6.1 Two interacting particles, 6.2 Rigid rotator, 6.3 Hydrogen atom, 6.4 Free particle radial function, 6.5 Particle in a spherical box, 6.6 Spherical potential well of finite depth, 6.7 Isotropic harmonic oscillator, 6.8 General results for two particles bound states.

7. **Matrix Representation:** 7.1 State vector, 7.2 Operators, 7.3 Continuous case, 7.4 Change of representations, 7.5 Eigenvalue problem, 7.6 Different representations, 7.7 Unitary transformations involving time, 7.8 Heisenberg matrix method: harmonic oscillator.

8. **Spin and Magnetic Moment:** 8.1 Need for matrix representation of spin, 8.2 Pauli spin matrices, 8.3 Spinors and expectation values, 8.4 Pauli operators, 8.5 Magnetic moment of an electron, 8.6 Precession of an electron in a magnetic field, Space inversion, time reversal, isospin.


**Spectroscopy:**

10. **Atomic Spectra:** 10.1 Quantum mechanics of hydrogen atom, 10.2 Hydrogen like spectrum, 10.3 Fine and hyperfine structure, 10.4 Spin orbit interaction in one and two valence electrons, 10.5 Doublet splitting and intensity ratio, 10.6 Doublet, normal and inverted terms, 10.7 Zeeman effect of two valence electrons, 10.8 Paschen Back effect: intensity and polarization rules, 10.9 Different types of coupling, 10.10 Width of a spectral line: natural breadth and collisional broadening.

11. **Molecular Spectra of Diatomic Molecules:** 11.1 Structure and theory of pure rotation and pure vibration, 11.2 Anharmonic oscillator, 11.3 Vibration-rotation spectra and electronic spectra, 11.4 Intensity variation of spectra, 11.5 Frank Condon principle, 11.6 Fortrail diagram, 11.7 Vibrational spectroscopy – IR and Raman spectra.

12. **X-ray Spectroscopy:** 12.1 X-ray spectra, 12.2 Emission and absorption spectra, 12.3 Energy levels, 12.4 Selection and intensity rules, 12.5 Fine structure, 12.6 Regular and irregular doublet’s law, 12.7 Multiple structure, 12.8 Satellites.
Text Books:


Reference Books:


Paper IV

Electromagnetism and Electronics

Course No.: Phy 514  Full Marks: 100
Nature of the course: Theory  Pass Marks: 40
Year : I

Course Description:
This course further develops on the theory and applications of electromagnetism and electronics.

Objectives:
The course will give an understanding of the formulation of the theory of electromagnetism and electronics, so that the students will be able to apply the knowledge in different situations, and also in higher studies and research.

Course Contents:

1. Electrostatic Field in Vacuum: 1.1 The electric field 1.2 The divergence and curl of electric field 1.3 Surface distribution of charges 1.4 Green’s theorem 1.5 Electrostatic potential and potential energy

2. Boundary Value Problems in Electrostatics: 2.1 Methods of image 2.2 Point charge in the presence of a (a) grounded conducting sphere (b) Charged insulated conducting sphere 2.3 Conducting sphere in a uniform electric field by method of image 2.4 Green function for the sphere, General solution for the potential 2.5 Conducting sphere with hemisphere at different potentials 2.6 Boundary value problems with azimuthal symmetry 2.7 Boundary value problems in cylindrical coordinates 2.8 Expansion of Green function in spherical coordinates 2.9 Expansion of Green function in cylindrical coordinates

3. Multipoles, Electrostatics of Macroscopic Media, Dielectrics: 3.1 Multipole expansion 3.2 Elementary treatment of electrostatics with ponderable media 3.3 Boundary value problem with dielectrics 3.4 Molecular polarizability and electric susceptibility 3.5 Models for the molecular polarizability 3.6 Electrostatic energy in dielectric media

4. Magnetostatics: 4.1 Biot and Savart law 4.2 Ampere’s law 4.3 Vector potential 4.4 Magnetic fields of a localized current distribution, magnetic moment 4.5 Force and torque on the energy of a localized current distribution in an external magnetic induction,
4.6 Macroscopic equations, Boundary conditions on B and H, 4.7 Method of solving boundary value problems in magnetostatics 4.8 Uniformly magnetized sphere 4.9 Magnetized sphere in an external field, permanent magnets

5. **Maxwell’s Equations:** 5.1 Development of Maxwell’s equations 5.2 Maxwell’s displacement current 5.3 Vector and scalar potentials 5.4 Gauge transformations 5.5 Green functions for the wave equation 5.6 Poynting’s theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields 5.7 Conservation laws for macroscopic media

6. **Electromagnetic Waves and Wave Propagation:** 6.1 Plane waves in nonconducting medium 6.2 Linear and circular polarization 6.3 Reflection and Refraction of electromagnetic waves at a plane interface between dielectrics 6.4 Total internal reflection 6.5 Waves in a conductive and dissipative medium 6.6 Wave guides

7. **Introduction to Scalar Diffraction Theory**

**Analog Electronics:**

**Circuit Theory:**

8 (a) **Network Transformation:** 8.1 Network definition, 8.2 Mesh and node network, 8.3 Principle of Duality, 8.4 Reduction of complicated network, 8.5 Conversion between T and II sections, 8.6 The bridge T– network, 8.7 The lattice network, 8.8 The reciprocity theorem, 8.9 Brief revision of Thevin’s and Norton’s Theorem, 8.10 The compensation Theorem, 8.11 The driving point impedance, 8.12 A.C. bridge (Lattice network) Sensitivity in bridge measurement, 8.13 The Parallel – T networks and network calculation using matrices

(b) **Resonance:** 8.14 Q-factor, 8.15 Series resonance and Band width of the series resonant circuit, 8.16 Parallel resonance circuit or anti-resonance, Condition for maximum impedance, Current in anti-resonant circuits, and impedance variation with frequency, 8.17 Band width of anti- resonant circuits, 8.18 The general case-resistance present in both branches and anti-resonance at all frequencies, 8.19 Reactance curves, Foster’s reactance network, and non-dissipative network design using Foster’s methods.

**Semiconductor Circuit Response and Design:**

9 (a) **Frequency response:** 9.1 Definition and basic concepts, 9.2 Decible and Logarithmic plots, 9.3 Series capacitance and low frequency response, Shunt capacitance and high
frequency response, 9.4 Transient response, Low and high frequency response of BJT amplifiers, Low and high frequency response of FET amplifiers.

(b) Integrated, Differential and Operational Amplifier Circuits: 9.5 Introduction, The ideal Differential amplifier (BJT and FET), Common mode parameters, 9.6 Practical differential amplifier, 9.7 Introduction to operational amplifiers and its circuit analysis.

10 (a) Operational Amplifier Theory: 10.1 The ideal operational amplifier, 10.2 Feedback theory, 10.3 Frequency response, Slew rate, Offset current and voltages.

(b) Application of Operational Amplifiers: 10.4 Voltage summation, subtraction and scaling, 10.5 Controlled voltage and current sources, 10.6 Integration, 10.7 Differentiation and wave-shaping, 10.8 Instrumentation amplifiers, 10.9 Oscillators (The Bark-Hausen criterion, RC phase shift oscillator, Wein bridge and crystal oscillator), 10.10 Active filters and its design, 10.11 Voltage comparators, Clipping, Clamping and rectifying circuits.

(c) Power Supply and Voltage Regulators: 10.12 Introduction, Rectifiers and different types of filters, 10.13 Voltage multipliers, Series and shunt voltage regulators, Switching regulators, 10.14 Different types Integrated circuit regulator (Three – terminal type and adjusted type)

Digital Electronics:

11 (a) Digital Circuit Analysis and Design: 11.1 Introduction, Boolean laws and theorem, Sum of Products methods, Truth table to Karnaugh map, Pairs, quads and octets, Karnaugh’s simplification.

(b) Data Processing Circuits: 11.2 Multiplexers, 11.3 De-multiplexers 1 of 16 decoder, 11.4 BCD to decimal decoders and Seven segment decoders, 11.5 Encoders, 11.6 Exclusive OR gates, 11.7 Parity generators-Checkers and read only memory.

(c) Numbers, System and Codes: 11.8 Binary numbers, Conversions of binary number to decimal number and vice versa, 11.9 Octal number and their inter conversion, 11.10 Hexadecimal numbers and conversion of hexadecimal to binary and vice versa, 11.11 Different Codes (the ASCII code, the excess- 3code, the Gray code).

12 (a) Arithmetic Circuits: 12.1 Binary addition and subtraction, unsigned binary numbers, Sign – magnitude numbers, 2’s compliment representation and its arithmetic, 12.2 Arithmetic building block, 12.3 The adder and subtractor, 12.4 Binary multiplication and division.

(b) TTL Circuits: 12.5 Digital integrated circuits, 7400 Devices, 12.6 TTL Parameters and TTL overview, gates, Open collector gates, 12.7 Three state TTL device, External drive for TTL loads and TTL driving external loads, 12.8 Positive and negative logic
(c ) Clock and Timers: 12.9 Clock Waveforms, 12.10 TTL Clock, 12.11 Timer - Astable and Monostable, Mono-stable with input logic, 12.12 Contact bounce circuit and some applications


(b) Shift Registers: 13.5 Types of registers, (Serial in – Serial out Serial in- Parallel out, Parallel in- Serial out, Parallel in – Parallel out), 13.6 Ring counters.


Text Books:


Reference Books:


5. Ryder, J.D. – Electronic Fundamental and Application, Prentice Hall of India Private Ltd., New Delhi (1979)


Physics Laboratory (Practical)

Course No.: Phy 515(A&B)                                                   Full Marks: (50+50)
Nature of the course: Practical                                           Pass Marks: (20+20)
Year : I

Course Description:

Practical course consists of two sections Phy 515A and Phy 515B. The first section Phy 515A
deals with general laboratory covering experiments on Nuclear physics, Atomic and Molecular
physics, and Spectroscopy. The second section Phy 515B covers experiments on analog and
digital electronics.

In the M.Sc. physics first year, students have to perform 15 experiments in each of the two
sections. They have to write a laboratory report on each experiment they perform and get them
duly checked and signed by the concerned teacher. They should write their reports in a separate
sheet, and to keep them neat and properly filed. Both the sections Phy 515A and Phy 515B will
be examined for the duration of six hours and students must pass both the sections separately.

Course Objectives:

- To provide students with skill and knowledge in the experimental methods.
- To make them able to apply knowledge to practical applications.
- To make them capable of presenting their results/conclusions in a logical order.
Course Contents:

Phy 515A: General Experiments

<table>
<thead>
<tr>
<th>No.</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>To study the Fresnel biprism for the determination of the wavelength of a given monochromatic light and thickness of mica sheet.</td>
</tr>
<tr>
<td>2.</td>
<td>To study Lloyd’s mirror for the determination of wavelength of Hg light.</td>
</tr>
<tr>
<td>3.</td>
<td>To study the working of fine beam tube for the determination of the specific charge of an electron.</td>
</tr>
<tr>
<td>4.</td>
<td>To study the Michelson Interferometer to determine: i) the wavelength of monochromatic light and ii) the thickness of the mica sheet.</td>
</tr>
<tr>
<td>5.</td>
<td>To study the formation of fringe pattern by wedge shape.</td>
</tr>
<tr>
<td>6.</td>
<td>To study the variation of refractive index with concentration of sugar solutions using a hollow prism.</td>
</tr>
<tr>
<td>7.</td>
<td>To study the phenomenon of hysteresis loss of the material and to determine the hysteresis loss of the material over a cycle.</td>
</tr>
<tr>
<td>8.</td>
<td>To study the absorption of β-particle by material to estimate the end-point energy of the β-particle.</td>
</tr>
<tr>
<td>9.</td>
<td>To study the absorption of γ-ray by the material of lead to determine its linear absorption coefficient, μ.</td>
</tr>
<tr>
<td>10.</td>
<td>To determine the half life of the radioactive source.</td>
</tr>
<tr>
<td>11.</td>
<td>Use $^{90}$Sr and $^{213}$Po β-sources (or, any two β-sources) and compare their activities using aluminum absorber and GM tube.</td>
</tr>
<tr>
<td>12.</td>
<td>To study the working of magnetron for the determination of the specific charge of an electron.</td>
</tr>
<tr>
<td>13.</td>
<td>To study the Lissajous pattern for the determination of the frequency of a given unknown source.</td>
</tr>
<tr>
<td>14.</td>
<td>To use the microwave source for studying the phenomenon of (a) Refraction, (b) Interference, (c) Diffraction, and (d) Polarization.</td>
</tr>
<tr>
<td>15.</td>
<td>To design and study the series and parallel LCR circuits for finding the quality factor of the elements.</td>
</tr>
</tbody>
</table>
1. To construct CE amplifier for the determination of the voltage gain of the amplifier.
2. To design and construct CC amplifier for estimating input and output impedance.
3. To construct regulated power supply and to study its output and input waveforms and to find the ripple factor.
4. To study the characteristics of a Zener diode and use it to construct the power supply.
5. To construct astablemultivibrator and to study its performance.
6. To construct monostablemultivibrator and to study its function.
7. To construct differential amplifier and estimate its CMRR (Common mode rejection ratio).
8. To study operational amplifier for its input-output waveform and use it as an integrator and differentiator.
9. To study the characteristic of a FET and construct it to work as an amplifier.
10. To construct a voltage doubler and study its characteristics.
11. To construct and to study the characteristics of RS flip-flop.
12. To construct and to study the working of NOT, AND, OR, NAND and NOR gates.
13. To construct and to study the exclusive OR, NAND and NOR gates.
14. To construct D/A converter and to study its working.
15. To study the working of half adder and full adder.
Books for Library

Text Books:


Reference Books:


**Text Books:**


**Reference Books:**


**Text Books:**


**Reference Books:**


**Reference Books:**