Minor/ CORE Courses (for 3 year MDP)

Semester 1

Minor 1/Core 1

Mechanics (Theory)

PHSMIN101T/PHSCOR101

45 Lectures **3 Credits**

Vectors **10 Lectures**

Vector algebra, scalar and vector products, derivatives of a vector with respect to a parameter, ordinary differential equations: 1st order homogeneous differential equations, 2nd order homogeneous and inhomogeneous differential equations with constant coefficients.

Particle Dynamics **14 Lectures**

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Gravitation **7 Lectures**

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

Oscillations **7 Lectures**

Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Forced harmonic oscillations, resonance.

Elasticity **8 Lectures**

Hooke's law: stress-strain diagram. Elastic moduli– relation between elastic constants; Poisson's Ratio; expression for Poisson's ratio in terms of elastic constants. Work done in stretching and work done in twisting a wire – twisting couple on a cylinder. Determination of Rigidity modulus by static torsion. Torsional pendulum. Bending of beam.

Reference:

1. Introduction to Mathematical Physics. C. Harper, 1989, PHI.

2. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

4. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

5. Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age

6. Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, 1979, Tata McGraw-Hill

7. Elements of Properties of Matter, D.S. Mathur, 2008, S. Chand and Company Limited

Mechanics (Minor 1/Core 1) Lab

PHSMIN101P/PHSCOR101P

60 lectures **2Credits**

List of Experiments:

1.To determine the Moment of Inertia of a regular body using another auxiliary body and a cradle suspended by a metallic wire.

2. To determine g and velocity for a freely falling body using Digital Timing Technique.

3. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

4. To determine the Young's Modulus by flexure method.

5. To determine the Modulus of Rigidity of a wire by a torsional pendulum.

6. To determine the value of g using Bar Pendulum.

7. To determine the value of g using Kater's Pendulum.

Reference:

1. An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 8th ed., 2007, New Central Book Agency

2. Advanced Practical Physics, vol 1, B. Ghosh & K. G. Mazumdar, 7th ed., Sreedhar Publishers, 2006

Semester 2

Minor 2/Core 2

Electricity and Magnetism (Theory)

PHSMIN202T/PHSCOR202T

45 Lectures **3 Credits**

Vector Analysis **10 Lectures**

Gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

Electrostatics **16 Lectures**

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field. Electric potential due to an electric dipole. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Magnetism **9 Lectures**

Magnetostatics: Biot-Savart's law & its applications– straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential.

Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

Electromagnetic Induction **5 Lectures**

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

Linear Network **5 Lectures**

Impedance of L, C, R and their combinations. Thevenin & Norton's Theorem. Maximum power transfer theorem and superposition theorem. Anderson's bridge.

Reference:

1. Vector Analysis with an Intro. to Tensor Analysis: Schaum's Outline Series. M.R. Spiegel, McGraw Hill.

2. Foundations of Electromagnetic Theory. J.R. Reitz, F.J. Milford and R.W. Christy, 2010, Pearson.

3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

4. Electricity and Magnetism, vol. 1, J. H. Fewkes and J. Yarwood, 2nd. ed., 1965, Oxford University Press

5. Electromagnetism. I.S. Grant and W.R. Phillips, 2013, Wiley.

6. Classical Electromagnetism. J. Franklin, 2008, Pearson Education.

7. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

8. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill.

9. A text book in Electrical Technology, B L Theraja, S Chand and Co.

Electricity and Magnetism (Minor 2/Core 2) Lab

PHSMIN202P/PHSCOR202P

60 lectures **2 Credits**

List of Experiments:

1.To determine an unknown Low Resistance using Carey Foster's Bridge.

2. To verify the Thevenin and Norton theorems.

3. To verify the Superposition and Maximum Power Transfer theorems.

4. To determine self-inductance of a coil by Anderson's bridge.

5. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

6. To determine an unknown Low Resistance using Potentiometer.

7. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

Reference:

1. An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 8th ed., 2007, New Central Book Agency

2. Advanced Practical Physics, vol 1, B. Ghosh & K. G. Mazumdar, 7th ed., Sreedhar Publishers, 2006

Minor 3/Core 3

Fluids and Waves (Theory)

PHSMIN303T/PHSCOR303T

45 lectures **3 Credits**

Fluids **5 lectures**

Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature.

Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of a liquid with temperature.

Superposition of Harmonic Oscillations **6 lectures**

Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal frequency and their uses.

Wave Motion – General **5lectures**

Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Wave intensity.

Wave optics **2 lectures**

Electromagnetic nature of light. Concept of wave front. Huygens Principle.

Interference and Interferometer **10 lectures**

Division of amplitude and wavefront. Young's double slit experiment. Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Michelson Interferometer (No analytical derivation). Applications of Michelson interferometer. Fringes of Equal Inclination. Fabry-Perot interferometer. Visibility of Fringes.

Diffraction **13 lectures**

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Polarization **4 lectures**

Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

Reference:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

2. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

3. Advanced Acoustics, D.P.Ray Chaudhury, The New Book Stall

4. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

5. Optics. E. Hecht, 2003, Pearson Education.

6. Principles of Optics, B.K. Mathur, 1995, Gopal Printing

7. Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age.

Minor 3/CORE3

Fluids and Waves (Lab)

PHSMIN303P+PHSCOR303P

60 lectures **2 Credits**

List of Experiments:

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T

law.

2. To study Lissajous Figures to determine the phase difference between two harmonic oscillations.

3. To determine the angle of prism and refractive index of the Material of a prism using sodium source.

4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury

source.

5. To determine wavelength of sodium light using Newton's Rings.

6. To determine wavelength of Na source using plane diffraction grating.

7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

Reference:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

2. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Publications.

3. An Advanced Course in Practical Physics, D Chattopadhyay and P.C.Rakshit, New Central Book

Agency.

4. A Text book on Practical Physics, K.G. Majumder and B.Ghosh, Sreedhar Publishers.

Thermal Physics and Statistical Mechanics (Theory) PHSCOR404T

45 Lectures **3 Credits**

Laws of Thermodynamics **22 Lectures**

Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between Cp and Cv, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials **7 Lectures**

Internal Energy, Enthalpy, Gibbs free energy and Helmholtz free energy, Maxwell's relations and applications– Joule-Thompson Effect, Clausius-Clapeyron Equation, General relation between Cp and Cv, TdS equations.

Kinetic Theory of Gases **7 Lectures**

Maxwell-Boltzmann Law of distribution of speed in an Ideal Gas (derivation required), Mean, RMS and Most Probable Speeds. Degrees of Freedom, Law of Equipartition of Energy (no proof required), Specific Heats of Gases: mono-atomic and diatomic gases, Mean Free Path and estimates of Mean Free Path.

Transport Phenomena: Viscosity, Conduction and Diffusion (no derivation required).

Statistical Mechanics **9 Lectures**

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Classical statistics – Boltzmann distribution; Quantum statistics (qualitative discussion only) - Fermi-Dirac distribution law (statement only) - electron gas as an example of Fermi gas: Low temperature specific heat of electron gas (order of magnitude estimate); Bose-Einstein distribution law (statement only) - photon gas as an example of Bose gas- comparison of three statistics.

Reference:

1. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford Univ Press

2. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

3. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

4. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

5. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill

6. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa

7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

8. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand

Thermal Physics and Statistical Mechanics (Core 4) Lab

PHSCOR404P

60 Lectures **2Credits**

1. Verification of Stefan's law using a torch bulb.

2 Credits

2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's method.

3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT) using constant current source.

4. Measurement of unknown temperature using Diode sensor.

5. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.

6. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.

Reference:

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Core 5
Modern Physics (Theory)
PHSCOR505T
60 Lectures
Elements of Special Relativity

60 Lectures **5 Credits**

Elements of Special Relativity **8 Lectures**

Brief summary of Lorentz transformation and time dilation, length contraction, velocity addition etc. (no derivation required). Elastic collision between two particles as
observed from two inertial frames with relative velocity, idea of relativistic momentum and relativistic mass. Mass-energy equivalence.

Quantum Theory of Light **4 Lectures**

Review on the limitations of classical theory of electromagnetic radiation within a cavity and its solution by Planck's quantum hypothesis (no derivation required).
Statement of Planck's law of black body radiation. Photoelectric effect. Einstein's postulate on light as a stream of photons. Compton's scattering and its explanation.

Bohr's model **3 Lectures**

Limitations of Ruherford's model of atomic structure. Bohr's model, its successes and limitations. Moseley's law: explanation from Bohr's model.

Wave-particle Duality **3 Lectures**

De Broglie's hypothesis – wave particle duality. Davisson-Germer experiment. Connection with Einstein's postulate on photons and with Bohr's quantization postulate for stationary orbits. Heisenberg's uncertainty relation as a consequence of wave-particle duality. Demonstration by γ-ray microscope thought experiment. Estimating minimum energy of a confined particle using uncertainty principle.

Wavefunction Description **3 Lectures**

Two slit interference experiment with photons, atoms & particles; linear superposition principle of associated wave functions as a consequence; Departure from matter wave interpretation and probabilistic interpretation of wave function; Schroedinger equation for non-relativistic particles; Momentum and Energy operators; stationary states. Properties of wave function. Probability and probability current densities in one dimension.

Stationary State Problems **7 Lectures**

One Dimensional infinitely rigid box, energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example. Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier: boundary conditions.

Atomic Physics **12 Lectures**

Quantization rules energy and orbital angular momentum from Hydrogen and Hydrogen like atoms (no derivation); s, p, d shells-subshells. Space quantization. Orbital Magnetic Moment and Magnetic Energy of electron, Gyromagnetic Ratio and Bohr magneton. Zeeman effect.

Electron Spin as relativistic quantum effect (qualitative discussion only), Spin Angular Momentum. Spin Magnetic Moment. Stern-Gerlach Experiment. Larmor Precession. Spin-orbit interaction. Addition of angular momentum (statement only). Energy correction due to relativistic effect and spin-orbit ineraction (statement only). Fine-structure splitting. Multi-electron atoms. Pauli's Exclusion Principle (statement only). Spectral Notations for atomic States. Aufbau principle, n+l rule (qualitative discussion only). Periodic table.

Nuclear Physics **15Lectures**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph. Binding energy curve. Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay, beta decay, gamma emission – basic characteristics. Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Basic principle of a nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and basic principle of thermonuclear reactions.

Structure of Solids **5Lectures**

Amorphous and crystalline solids. Lattice structure of crystalline (no categorisation required). Unit cell and basis vectors of a lattice. Diffraction of X-ray by crystalline solid. Bragg's law.

Reference:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. R. Eisberg and R. Resnick, 1985, Wiley.
2. Concept of Modern Physics. 6 ed., A. Beiser, 2003, McGraw-Hill.
3. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
4. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
5. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.

Semester-6
Core 6
Analog and Digital Electronics (Theory)
PHSCOR606T

45 Lectures **3 Credits**

Semiconductor Devices and Amplifiers **10 Lectures**

Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplifier.H-parameter, Equivalent Circuit.Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

Operational Amplifiers (Black Box approach) **12 Lectures**

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator.

Instrumentations **13 Lectures**

Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. Power Supply: Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. Timer IC: IC 555 Pin diagram and its application as Astable Multivibrator.

Digital Circuits **10 Lectures**

NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map Binary Addition. Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

Reference:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronic devices & circuits, S. Salivahanan& N.S. Kumar, 2012, Tata Mc-Graw Hill
3. Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
4. Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
5. Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.
6. OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

Analog and Digital Electronics (Core 6) Lab
PHSCOR606P

60 Lectures **2 Credits**

List of Experiments:

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO

2. To study IV characteristics of PN diode, Zener and Light emitting diode
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. To minimize a given logic circuit.
5. Half adder, Full adder and 4-bit Binary Adder.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
9. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
10. To investigate a differentiator made using Op-amp.

Reference:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4th Edn, 2000, Prentice Hall.
4. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
5. Advanced Practical Physics Vol.-II, B. Ghosh, Sreedhar Publishers

Semester-7
S Minor-1
PHSSMC01T
Solid State Physics (Theory)

45 Lectures **3 Credits**

Elements of Modern Physics **8 Lectures**

Brief introduction to limitations of classical physics and advent of quantum physics. Brief review of Bohr's atomic model and photoelectric effect. Einstein's postulate on light as a stream of photons. Davisson-Germer experiment. De Broglie's hypothesis – wave particle duality. Schroedinger equation for non-relativistic particles. Probabilistic interpretation of wave function. Particle moving in one dimensional box: energy eigenvalues and eigenfunctions; normalization. Statistical behavior of a many particle system: idea of distribution function. Maxwell-Boltzman distribution law (statement only): example of velocity distribution in an ideal gas (qualitative). Classical equipartition theorem (statement only). Distribution function for quantum paticles: Fermi-Dirac and Bose-Einstein distributions (statement only). Examples of fermions and bosons.

Crystal Structure **8 Lectures**

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Laue's condition and Bragg's Law.

Elementary Lattice Dynamics **7 Lectures**

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustic and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids.

Dulong and Petit's Law, its limitations. Einstein's theory of specific heat of solids, its limitations. Debye's correction (qualitative idea), T3 law (statement only).

Free electron theory of Metals **8 Lectures**

Free electron gas in metals: Drude's theory, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory. Sommerfield correction to free electron theory in a Metal: Fermi Energy – dependence on density, Fermi temperature, Fermi momentum. Ground state energy. Electronic specific heat at low temperatures (explanation of linear behavior in T using exclusion principle).

Elementary band theory **5 Lectures**

Idea of electronic energy bands using the Kronig Penny model. Band Gap. Classification of Conductor, Semiconductor (intrinsic, as well as P and N types) and Insulator. Conductivity of Semiconductor, mobility, Hall Effect.

Magnetic Properties of Matter **6 Lectures**

Dia-, Para-, and Ferromagnetic Materials. Classical Langevin Theory of dia- and Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Superconductivity **3 Lectures**

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors.

Reference:

1. Concepts of Modern Physics, Arthur Beiser, 6th Edition, 2005, Tata McGraw Hill
2. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
3. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
4. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

5. The Oxford Solid State Basics. S. H. Simon, 2013, Oxford.
6. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Minor-1

Solid State Physics Lab

PHSSMC701P

60 Lectures **2 Credits**

List of Experiments:

1. To draw the B-H curve of Fe using Solenoid & determine energy loss from Hysteresis.
2. To measure the resistivity of a semiconductor (Ge) with temperature by reverse bias characteristics of a Ge diode (room temperature to 80oC) and to determine
its band gap.
3. To determine the Hall coefficient of a doped semiconductor sample.
4. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
5. To measure the Magnetic susceptibility of paramagnetic Solids (Gouy's Method).

Skill Enhancement Courses

Physics

Semester 1/Semester 3

SEC (Physics) 1

Basic Instrumentation Skills

PHSHSE101M/PHSMSE01M/ PHSGSE301M/ PHSGSE501M

45 Lectures **3 Credits**

1. Basic of Measurement

Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

2. Electronic Voltmeter

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier-rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance.

3.Cathode Ray Oscilloscope

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), briefdiscussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

4. Signal Generators and Analysis Instruments

Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

5.Digital Instruments

Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

6. Digital Multimeter

Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time base stability, accuracy and resolution.

- **The test of lab skills will be of the following test items:**

1. Use of an oscilloscope.
2.CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Trouble shooting a circuit
8. Balancing of bridges

- **Laboratory Exercises**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.

3. Measurement of voltage, frequency, time period and phase angle using CRO.
4. Measurement of time period, frequency, average period using universal counter/ frequency counter.
5. Measurement of rise, fall and delay times using a CRO.
6. Measurement of distortion of a RF signal generator using distortion factor meter.

Reference:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
7. Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
9.

Semester 2/ Semester 4
SEC (Physics) 2
Computational Physics Skills
PHSHSE202M/PHSGSE402M/PHSGSE602M

45 Lectures **3 Credits**

Introduction

Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

Scientific Programming

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN/ C++, Basic elements of FORTRAN 90/95 or C++: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran 90/95 or C++ Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

Control Statements

Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements, Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming

1. Exercises on syntax on usage of FORTRAN 90/95 or C++

2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN 90/95 or C++.

3. To print out all natural even/ odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.

5. Calculating Euler number using exp(x) series evaluated at x=1

Scientific word processing: Introduction to LaTeX

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

Visualization

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined ariables and functions), Understanding data with Gnuplot

Hands on exercises

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.

9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for

Reference:

1. Computer Programming in Fortran 90 and 95. V. Rajaraman, 1997 (Publisher: PHI).
2. Object Oriented Programming with C++. E. Balaguruswamy, 2017. McGraw Hill, India.
3. LaTeX–A Document Preparation System, Leslie Lamport (Second Edition, Addison- Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)

MDC (Physics)
Current perspectives of Physics
PHSHMD101M/PHSHMD201M/PHSHMD301M
PHSGMD401M/PHSGMD501M/PHSGMD601M

45 Lectures **3 Credits**

Course objective: To give an overview of some basic physical ideas at a semi-popular level – with minimal use of mathematics.
Course Pre-requisites: High school level exposure of physical science, algebra and geometry.

Module 1

1(a) Introduction : **2 lectures**

Qualitative idea of Systems, Observers, Reference frames and Forces originating from the fundamental Interactions of nature, long-range (gravity and electromagnetic) and short-range (strong and weak forces).

1(b) How Physics works: **12 lectures**

Examples of how observations lead to discovery of Laws of nature, how theories are constructed around these laws, how experiments verify theoretical predictions and theories are modified to suit the experimental findings.

Examples:

● Galilean and Newtonian Dynamics giving Laws of motion, Kepler's laws of Planetary motion explained by Newton's theory of gravity, Discovery of Neptune as a verification of Newton's gravity theory, Newton's gravitational constant. [3 lectures]

● Different empirical laws of Electromagnetism (Coulomb's law, Faraday's law, Ampere's law etc) connected by Maxwell's theory, Prediction of electromagnetic wave and its speed of propagation as a Universal constant. Inconsistency with laws of Galilean Relativity leading to discovery of Special Relativity. [4 lectures]

● Observation of atomic spectra and Black-body radiation leading to Planck's quantum theory and Einstein's explanation of Photoelectric effect introducing Photon as a "quanta of energy"(Details to be covered in Module 3). Discovery of Bohr model of atom. Development of quantum mechanics, Planck's constant – a fundamental constant of nature. [5 lectures]

Module 2

The grand scheme of Physics: **13 Lectures**

The three fundamental constants of nature, c, G and . (= 0, G = 0, = 0) : Classical non-relativistic mechanics: the starting point. (= 1, G = 0, = 0) : Classical relativistic mechanics, SR, Electrodynamics (mention basic technologies like, cars, electricity, energy industry) [1 lecture] (= 0, G = 1, = 0) : Classical Newtonian gravity, falling bodies, Structure of solar system, Galaxies. [1 lecture] (= 0, G = 0, = 1) : Non-relativistic quantum mechanics, basic structure of atoms, molecules, solid state physics. (Qualitative) (mention modern application in electronic and data storage devices, e.g., computers, mobiles). [4 lectures] (= 1, G = 1, = 0) : Classical General relativity, curved spacetime, fine-tuning of planetary motion, perihelion precession of Mercury, deflection of light by the Sun, recent observational evidence of Black- holes and Gravitational waves as predicted by theory. (modern applications in communication, e.g. GPS, astronomical telescopes giving information about the cosmological structure of the Universe). [5 lectures] (= 1, G =0, = 1) : Relativistic quantum mechanics, it's inconsistencies leading to Quantum field theory which explains sub-atomic structures, fun- damental particles, standard model (LHC). (= 1, G =1, = 1) : Theory of Quantum Gravity, yet to be formalised. [2 lectures]
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Module 3

3(a) Light and it's dual nature: 10 lectures

Corpuscular and wave theories of light- a historical overview; merits and demerits of the two theories; simple experiments demonstrating dispersion of light using prism, diffraction of light with laser source, demonstration of Newton's rings and its qualitative explanation; naïve idea of black body radiation, Planck's proposal of energy quanta, photoelectric effect and particle nature of light;Scattering of light, Raman effect (qualitative).

3(b) The Electromagnetic Spectrum: 8 lectures

Introduction to the entire electromagnetic spectrum; Light as an electromagnetic wave (mention Maxwell's theory, Hertz's experiment); usage of different parts of the electromagnetic spectrum - with examples from everyday life including x-rays and gamma-rays in medical science, microwaves and radio waves (mentioning India's Radio telescope site at GMRT), preliminary concepts of LASER, Holography and Fibre optics.

Reference:

1. Perspectives of Modern Physics, Arthur Beiser, McGraw-Hill Inc.,US, 1969.
2. The Feynman Lectures on Physics - Vol. I, II & III, Pearson Education; Combo edition, 2012.
3. At the root of Things, The subatomic world, Palash B. Paul, CRC Press, 2014.
4. কী দি য়ে সমস্তদিকীছু গড়া, পলাশ বরন পলা, পশ্দি মবঙ্গ রজ্য পস্তকী পর্ষ ,২ সস্কীরণ, ১৯৯৭