Cooch Behar
Panchanan Barma
University

Syllabus for Physics

UNDER NEP 2020

Cooch Behar Panchanan Barma University

Cooch Behar, West Bengal

Preamble

University Grants Commission (UGC) introduced, in 2018, a major reform in the higher education sector in India. Accordingly, Learning Outcomes-based Curriculum Framework (LOCF) took the centre-stage to make the curriculum student-centric, interactive and outcome-oriented with well-defined aims and objectives. The Physics Undergraduate Board of Studies of Cooch Behar Panchanan Barma University took the initiative to implement the reforms and frame the syllabus so as to increase the spirit of enquiry, analytical ability and comprehension skills among the students.

Credit Scheme

Paper	Distribution of marks		
	Theory	Lab	Internal
Major	50	25	25
Minor	50	25	25
SEC		35	15
MDC	35		15
AEC	35		15
VAC	35		15

1^{st} SEM	Cr	2^{nd} SEM	Cr
Major-1	6	Major-2	6
Minor-1	6	Minor-2	6
MDC-1	3	VAC-1	3
SEC-1	3	SEC-2	3
AEC-1	4	INTRN	4
	22		22
CERTIFICATE	44		

3^{rd} SEM	Cr	4^{th} SEM	Cr
Major-3	6	Major-5	6
Major-4	6	Major-6	6
Minor-3	6	Minor-4	6
SEC-3	3	AEC-2	4
MDC-2	3		
	24		22
DIPLOMA	90		

5^{th} SEM	Cr	6^{th} SEM	Cr
Major-7	6	Major-10	6
Major-8	6	Major-11	6
Major-9	6	Major-12	6
MDC-3	3	VAC-2	3
	21		21
DEGREE			132

w/o RESEARCH

7^{th} SEM	Cr	8^{th} SEM	Cr
Major-13	6	Major-17	6
Major-14	6	Major-18	6
Minor-5	6	Minor-6	6
Major-15	6	Major-19	6
Major-16	6		
	30		24
DEGREE (HONOURS)			186

w RESEARCH

7^{th} SEM	Cr	8^{th} SEM	Cr
Major-13	6	Major-15	6
Major-14	6	Major-16	6
Minor-5	6	Minor-6	6
Research-1	6	Research-2	6
	24		24
DEGREE (RESEARCH)			180

MAJOR COURSES (PHYSICS)

Semester I

Physics - Major 1 : Mechanics and General Properties of Matter (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Vector Calculus Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and Curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes' Theorems and their applications (no rigorous proofs).

Orthogonal Curvilinear Coordinates: Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Fundamentals of Dynamics Reference frames. Inertial frames; Galilean transformations. Review of Newton's Laws of Motion. Projectile motion, Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum, Impulse. Momentum of variable-mass system: motion of rocket. Components of Velocity and Acceleration in plane polar, Cylindrical and Spherical Coordinate Systems.

Laws of physics in rotating coordinate systems, Centrifugal force. Coriolis force and its applications.

Work and Energy Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Stable and unstable equilibrium. Force as gradient of potential energy. Work done by non-conservative forces. Law of conservation of Energy. Elastic and inelastic collisions. Centre of Mass frame and Laboratory frame.

Rotational Dynamics Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Moment of Inertia, parallel and perpendicular axes theorem, moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Gravitation and Central Force Motion Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

Elasticity Hook's Law, Relation between Elastic constants. Poisons ratio, Strain energy in a stretched wire, Twisting torque on a Cylinder or Wire.

Fluid Motion Surface Tension: Surface Energy, Phenomena involving surface tension, Angle of Contact, Capillary rise.

Viscosity: Streamline flow, Turbulent motion, Stokes Law, Reynold's Number, Equation of Continuity, Bernoulli's Theorem, Poiseuille's equation for flow of a liquid through a Capillary Tube.

Special Theory of Relativity Michelson-Morley Experiment. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic addition of velocities. Variation of mass with velocity. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Reference Books

[1] R. Sengupta and H. Chatterjee, A Treatise on General Properties of Matter, New Central Agency.

[2] D.S. Mathur, Elements of Properties of Matter, S. Chand.

[3] R.P. Feynman, R.B. Leighton and M. Sands, The Feynman Lectures in Physics, vol.1, B I Publications.

[4] L. Pachuau and L. Sailo, A Textbook of Properties of Matter, Oscillations and Acoustics, PUC and GSC.

Physics - Major 1 Lab : Mechanics and General Properties of Matter 60 Lectures

Student should study the measurements of length (or diameter) using Vernier caliper, screw gauge and travelling microscope.

Experiments

1. To determine the height of a building using a Sextant.
2. To study the motion of Spring and calculate (a) Spring constant; (b) Acceleration due to Gravity.
3. To determine the Modulus of Rigidity of material of a cylindrical wire by Statical Method.
4. To determine the Modulus of Rigidity of material of a cylindrical wire by Dynamical Method.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine the Moment of Inertia of a cylindrical/rectangular bar.
7. To determine the value of g and velocity for a freely falling body using Digital Timing Technique.
8. To determine the Coefficient of Viscosity of a viscous liquid using Stokes' Law.
9. To determine Coefficient of Viscosity of water by Poiseuille's flow Method.
10. To determine the Young's Modulus of a Bar by Flexure Method.
11. To determine the Young's Modulus of a Wire by Optical Lever Method.
12. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
13. To determine the Young's Modulus of a wire by Searle's method.
14. To determine the value of g using Bar Pendulum.
15. To determine the value of g using Kater's Pendulum.
16. To determine the surface tension of water by Jaeger's Method.

(A student should perform at least ten experiments from the above)

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann, 1985.
[3] I. Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] G.L. Squires, Practical Physics (4ed), Cambridge, 2015.

Semester II

Physics - Major 2 : Electricity and Magnetism
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Electric Field and Electric Potential Coulomb's Law, Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field and Potential. Potential energy of system of charges, Electrostatic energy of a charged sphere, Laplace's and Poisson equations. The Uniqueness Theorem. Electrostatic force on a charged particle. Electric dipole, Electric Potential and Field due to a dipole. Force, torque on a dipole, potential energy of a dipole. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Electric field in Conductor and Dielectric material Electric Field in conductor, Dielectric Polarisation ($\vec{P}$), Polarisation Charges. Electrical Susceptibility and Dielectric Constant. Displacement vector ($\vec{D}$). Relations between $\vec{E}, \vec{P}$ and $\vec{D}$. Gauss' Law in dielectrics.

Capacitance Capacitance of a conductor, Charging, discharging of a capacitor, Capacitance of parallel plate, spherical, cylindrical capacitor, combination of capacitors.

Magnetic Field Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to straight wire, Solenoid and Toroid. Properties of $\vec{B}$: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire. Torque on a current loop in a uniform Magnetic Field, Ballistic Galvanometer: Current and Charge Sensitivity, Electromagnetic damping, Logarithmic damping, CDR.

Magnetic Properties of Matter Magnetisation vector ($\vec{M}$). Magnetic Intensity ($\vec{H}$). Magnetic Susceptibility and Permeability. Relation between $\vec{B}, \vec{H}$ and $\vec{M}$. Dia-, Para- and Ferromagnetism. B-H curve and hysteresis.

Electromagnetic Induction Faraday's Law. Lenz's Law. Motional emf, eddy current, Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field.

Electrical Circuits DC Circuits: Transient phenomena, growth and decay of currents in LR, CR and LCR circuits. AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. LC oscillations, transformer.

Network theorems Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Reference Books

[1] H.K. Malik and A.K. Singh, Engineering Physics, McGraw Hill, 2018.

[2] D.J. Griffiths, Introduction to Electrodynamics (3ed), Prentice-Hall, 2002.

[3] E. M. Purcell, Electricity and Magnetism: Berkeley Physics Course vol. 2, McGraw Hill, 2017.

[4] D.C. Tayal, Electricity and Magnetism (4ed), Himalaya Publishing, 2019.

[5] D. Chattopadhyay and P.C. Rakshit, Electricity and Magnetism, Central Book Agency, 2005.

Physics - Major 2 Lab : Electricity and Magnetism
60 Lectures

Student should study the use a Multimeter for measuring (a) Resistances; (b) AC and DC Voltages; (c) Direct Current; (d) Capacitances; and (e) Checking electrical fuses.

Experiments

1. To determine an unknown Low Resistance using Potentiometer/fall of potential method.
2. To determine an unknown Resistance using Carey Foster's Bridge.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a solenoid (determine dB/dx).
5. To verify the Thevenin's and Norton's theorems.
6. To verify the Superposition, and Maximum power transfer theorems.
7. To determine self inductance of a coil by Anderson's bridge.
8. To study the ac characteristics of a series CR Circuit.
9. To study the ac characteristics of a series LR Circuit.
10. 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.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti resonance frequency; and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the self-inductance of two coils separately by using Anderson's Bridge and the total equivalent inductance when they are connected in series and hence estimate the coefficient of coupling between the two coils.
16. To determine the mutual inductance of two coaxial coils at different orientations using Ballistic Galvanometer.
17. To determine the horizontal component of the Earth's magnetic field and the magnetic moment of a magnet using a deflection and oscillation magnetometer.

(A student should perform at least ten experiments from the above)

Reference Books

[1] D. Chattopadhyay and P.C. Rakshit, Electricity and Magnetism, Central Book Agency, 2005.

[2] B. Ghosh, K.G. Mazumdar, Advanced Practical Physics, vol. 1, Sreedhar Publications, 2013.

Semester III

Physics - Major 3 : Waves and Optics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Mathematical Preliminaries Ordinary differential equation: Series solution of ordinary linear second order differential equation (outlines of methods of series solution without going in to proof), Legendre and Hermite polynomials and elementary properties of Legendre and Hermite polynomials (orthogonality and recurrence relation).

Partial differential Equations : Solution by the method of separation of variables, Laplace's equation and its solution in cartesian, spherical polar and cylindrical coordinates

Fourier series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Fourier Series: Periodic functions. Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.

Simple Harmonic Motion Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle. Lissajous Figures with equal and unequal frequencies, effect of variation of phase.

Damped and Forced Oscillations Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor.

Wave Motion One dimensional plane wave, classical wave equation, Travelling wave solution. Standing (Stationary) Waves in a String: Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. Newton's Formula for Velocity of Sound. Laplace's Correction.

Geometrical Optics Fermat's Principle. Cardinal point, Aberration, Dispersion. Optical instruments.

Wave nature of light Electromagnetic nature of light, Huygen's principle – derivation of laws of reflection and refraction . Temporal and Spatial Coherence.

Interference Division of amplitude and division of wavefront; Young's double slit experiment: width and shape of fringes; Fresnel's biprism; Lloyd's mirror; Phase change on reflection: Stokes' treatment; Interference in thin films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger fringes); Fringes of equal thickness (Fizeau Fringes); Newton's rings: Measurement of wavelength and refractive index.

Diffraction Fraunhofer diffraction: Single slit, double slit, diffraction grating Fresnel diffraction: Fresnel's assumptions. Fresnel's half-period zones for plane wave. Explanation of rectilinear propagation of light; Fresnel's diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Reference Books

[1] A.P. French, Vibrations And Waves, CBS, 2003.
[2] N.K. Bajaj, The Physics of Waves and Oscillations, Tata McGraw Hill, 1998.
[3] K. Uno Ingard, Fundamentals of Waves and Oscillations, Cambridge University Press, 1988.
[4] D. Kleppner and R. Kolenkow, An Introduction to Mechanics, Cambridge University Press, 2021.
[5] F. Crawford, Waves: Berkeley Physics Course, Vol 3, Tata McGraw-Hill, 2007.
[6] P.A. Dourmashkin, Classical Mechanics, Wiley, 2014.
[7] Resnick, Halliday and Walker, Physics (9ed), Wiley, 2010.
[8] R.P. Feynman, R.B. Leighton and M. Sands, Feynman Lectures, Vol 1, Pearson Education, 2008.
[9] H.D. Young and R.A. Freedman, University Physics (14ed), Pearson Education, 2017.
[10] G.B. Arfken, H.J. Weber, F.E. Harris, Mathematical Methods for Physicists (7ed), Elsevier, 2012.
[11] M.R. Spiegel, Fourier Analysis, Tata McGraw-Hill, 2004.
[12] A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics, Laxmi Publications, 2017.
[13] P.K. Chattopadhyay, Mathematical Physics (3ed), New Academic Science Ltd, 2008.

Physics - Major 3 Lab : Waves and Optics
60 Lectures

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures to find out the ratios of frequencies and phase determinations.
4. Familiarisation with: Schuster's focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.

10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine the wavelength of a monochromatic source using diffraction of single slit.
12. To determine the wavelength of a monochromatic source using diffraction of double slits.
13. To determine wavelength of a monochromatic source using plane diffraction grating.
14. To determine angular spread of He-Ne laser using plane diffraction grating.
15. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

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

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Physics - Major 4 : Analog Electronics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Semiconductor Diodes: P and N type semiconductors. Energy Level Diagram of Semiconductors. Conductivity and Mobility. Concept of Drift & Diffusion current. Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode.

Two-terminal Devices and their Applications: (1) Rectifier Diode: Half- wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Diode Clipping and Clamping circuits (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LED (2) Photodiode and (3) Solar Cell, (4) Tunnel Diode.

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Regulated Power Supply: Basic idea of Series and Shunt voltage regulation.

Field Effect Transistors: Characteristics and structure of JFET.

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model , Input and Output Impedance, Current, Voltage and Power Gains. Basic idea of Class A, Class B , Class C & Class AB Amplifiers.

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Hartley oscillator & Colpitts oscillator, determination of Frequency.

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder (3)Subtractor (4) Differentiator (5) Integrator (6) Log amplifier (7) Zero crossing detector (8) Wien bridge oscillator.

Conversion: Resistive network (Weighted and R-2R Ladder), Accuracy and Resolution. A/D Conversion (successive approximation)

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Amplitude Demodulation (diode detector). Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Reference Books

[1] J. Millman and C.C. Halkias, Integrated Electronics, Tata McGraw Hill, 1991.
[2] J.D. Ryder, Electronics: Fundamentals and Applications, Prentice-Hall, 2004.
[3] B.G. Streetman and S.K. Banerjee, Solid State Electronic Devices (6ed), PHI Learning, 2009.
[4] S. Salivahanan and N.S. Kumar, Electronic Devices and Circuits (3ed), Tata McGraw Hill, 2012.
[5] A.S. Sedra, K.C. Smith, A.N. Chandorkar, Microelectronic Circuits (6ed), Oxford University Press, 2014.
[6] U.Tietze and C.Schenk, Electronic Circuits: Handbook of Design and Applications, Springer, 2008.
[7] S.M. Sze, Semiconductor Devices: Physics and Technology (2ed), Wiley India, 2002.
[8] M.H. Rashid, Microelectronic Circuits (2ed), Cengage Learning.
[9] Thomas L. Floyd, Electronic Devices (7ed), Pearson India, 2008.

Physics - Major 4 Lab : Analog Electronics
60 Lectures

Experiments

1. To study V-I characteristics of PN junction diode or Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE (CC) transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response and voltage gain of a RC-coupled transistor amplifier.

7. To design a Wien bridge oscillator for given frequency using an OP-AMP.
8. To design a phase shift oscillator of given specifications using BJT.
9. To study the Colpitt's oscillator.
10. To design an inverting amplifier using Op-amp (741,351) for DC voltage of given gain.
11. To design inverting amplifier using Op-amp(741,351) and study its frequency response
12. To design non-inverting amplifier using Op-amp (741,351).
13. To add two DC voltages using OP-AMP in inverting and non-inverting mode
14. To design a precision Differential amplifier of given I/O specification using Op-amp.
15. To investigate the use of an OP-AMP as an Integrator.
16. To investigate the use of an OP-AMP as a Differentiator.
17. To design a circuit to simulate the solution of a 1st/2nd order differential equation.
18. To design an Amplitude Modulator and Demodulator using Transistor.
19. To study FM - Generator and Detector circuit.

Reference Books

[1] P.B. Zbar, A.P. Malvino, M.A. Miller, Basic Electronics: A Text Lab Manual, McGraw Hill, 1994.
[2] R.A. Gayakwad, OP-Amps and Linear Integrated Circuit (4ed), Prentice Hall, 2000.
[3] Albert Malvino, Electronic Principle, Tata McGraw Hill, 2008.
[4] R.L. Boylestad and L.D. Nashelsky, Electronic Devices And Circuit Theory, Pearson, 2009.

Semester IV

Physics - Major 5 : Heat and Thermodynamics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Mathematical preliminaries Some Special Integrals: Beta and Gamma functions and relations between them. Expansion and integrals in terms of Gamma functions. Error function.

Introduction to probability. Independent random variables: Sample space and probability distribution functions. Binomial, Gaussian and Poisson distribution with examples. Random walk in 1D.

Kinetic Theory of Gases: Distribution of Velocities; Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and Diffusion. Brownian Motion and its Significance.

Conduction of Heat: Thermal and thermometric conductivity, diffusivity, Fourier's equation for heat propagation and its solutions, periodic flow of heat, Measurement of thermal conductivity. Wiedemann-Franz law.

Real Gases: Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work and Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law and various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine and efficiency. Refrigerator and coefficient of performance, Second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetisation, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of CP-CV, (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Reference Books

[1] M.W. Zemansky, Richard Dittman, Heat and Thermodynamics, McGraw Hill, 1981.

[2] Meghnad Saha, and B.N. Srivastava, A Treatise on Heat, Indian Press, 1958.

[3] S. Garg, R. Bansal and Ghosh, Thermal Physics (2ed), Tata McGraw Hill, 1993.

[4] Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer, 2009.
[5] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[6] S.J. Blundell and K.M. Blundell, Concepts in Thermal Physics (2ed), Oxford University Press, 2012.
[7] A. Kumar and S.P. Taneja, Thermal Physics, R. Chand Publications, 2014.

Physics - Major 5 Lab : Heat and Thermodynamics
60 Lectures

Experiments

1. Determination of linear expansion coefficient of a solid by Optical Lever method.
2. Determination of the thermal conductivity of Glass in the form of tube.
3. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
4. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the Temperature Coefficient of Resistance of a copper coil/Platinum Resistance Thermometer.
8. To study the variation of Thermo-Emf of a Thermocouple with Difference of Tem perature of its Two Junctions.
9. To calibrate a thermocouple to measure temperature in a specified Range using (a) Null Method; and (b) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] D.P. Khandelwal, A Laboratory Manual of Physics for Undergraduate Classes, Vani Pub, 1985.

Physics - Major 6 : Digital Electronics
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Introduction to CRO Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: Study of Waveform, Measurement of Voltage, Current, Frequency, and Phase Difference.

Integrated Circuits (Qualitative treatment only) Active & Passive components. Discrete components. Wafer, Chip. Advantages and drawbacks of ICs, basic idea of Monolithic IC. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

Digital Circuits Advantage, Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map (up to four variable).

Data processing circuits Basic idea of Multiplexers, De-Multiplexers, Decoders, Encoders, Seven segment display and Digital Comparators.

Arithmetic Circuits Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Sequential Circuits SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip- Flop. Master-Slave JK Flip-Flop.

Timers IC 555: Block diagram and Applications: Astable multivibrator and Monostable multivibrator.

Shift registers Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Counters (4 bits) Ring Counter. Asynchronous Counters, Decade Counter. Synchronous Counter, Applications.

Computer Organisation Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

Intel 8085 Microprocessor Architecture Main features of 8085. Block diagram. Components. Pin-out diagram, Buses. Registers, ALU, Memory, Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

Introduction to Assembly Language 1 byte, 2 byte and 3 byte instructions.

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantizing and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

Reference Books

[1] A.P. Malvino, D.P. Leach and Saha, Digital Principles and Applications (7ed), Tata McGraw Hill, 2011.
[2] Anand Kumar, Fundamentals of Digital Circuits, PHI Learning, 2009.
[3] Venugopal, Digital Circuits and Systems, Tata McGraw Hill, 2011.

[4] G.K. Kharate, Digital Electronics, Oxford University Press, 2010.
[5] R.J. Tocci and N.S. Widmer, Digital Systems: Principles and Applications, PHI Learning, 2001.
[6] Shimon P. Vingron, Logic Circuit Design, Springer, 2012.
[7] Subrata Ghoshal, Digital Electronics, Cengage Learning, 2012.
[8] S.K. Mandal, Digital Electronics, McGraw Hill, 2010.
[9] R.S. Goankar, Microprocessor Architecture Programming and Applications with 8085, Prentice Hall, 2002.

Physics - Major 6 Lab : Digital Electronics
60 Lectures

Experiments

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder IC.
8. To design a digital to analog converter (DAC) of given specifications.
9. To study the analog to digital convertor (ADC) using ICs.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs.
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. To study ASK, PSK and FSK modulators.
17. Write the following programs using 8085 Microprocessor
    (a) Addition and subtraction of numbers using direct addressing mode.
    (b) Addition and subtraction of numbers using indirect addressing mode.
    (c) Multiplication by repeated addition.
    (d) Division by repeated subtraction.
    (e) Handling of 16-bit Numbers.
    (f) Use of CALL and RETURN Instruction.
    (g) Block data handling.
    (h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books

[1] R.P. Jain, Modern Digital Electronics (4ed), Tata McGraw Hill, 2010.
[2] P.B. Zbar, A.P. Malvino, M.A. Miller, Basic Electronics: A Text Lab Manual, McGraw Hill, 1994.
[3] R.S. Goankar, Microprocessor Architecture Programming and Applications with 8085, Prentice Hall, 2002.
[4] A. Wadhwa, Microprocessor 8085: Architecture, Programming and Interfacing, PHI Learning, 2010.

Semester V

Physics - Major 7 : Electromagnetic Theory
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Maxwell's Equations Review of the Gauss' law and Faraday's law. Ampére's law beyond magnetostatics and its rectification by Maxwell. Concept of Displacement Current Density. Maxwell's Equations. Poynting Theorem and Poynting Vector. Derivation of Electromagnetic Field Energy Density, Momentum Density, Intensity of EM Wave and Radiation Pressure.

EM Wave Propagation in unbounded media Wave equations for and fields in free space and dielectric media. Solution of the EM wave equations: Monochromatic plane wave. Transverse nature of the plane EM wave. Derivation of the relation connecting field, field and propagation vector. Plane EM waves through isotropic dielectric medium, Refractive index and Dielectric constant. Propagation through conducting media, Relaxation time, Skin Depth and ratio of amplitudes of and fields. Wave Guides, TE waves, TEM waves. TE waves in Rectangular Wave Guide: Cutoff frequency, Propagation speed of EM wave down the Wave Guide.

EM Wave Propagation in bounded media Boundary conditions for the EM wave at a plane interface between two media. Reflection and Refraction of plane waves at plane interface between two dielectric media. Derivations of the Laws of Reflection and Refraction. Fresnel's formulae for perpendicular and parallel polarization cases, Derivations of reflection and transmission coefficients, Brewster's law. Total internal reflection, evanescent waves. Mathematical description of Metallic reflection (for Normal Incidence).

Polarization Polarization by dichroic crystals, birefringence, Nicol prism, retardation plates and Babinet's compensator. Analysis of polarized light. Optical Rotation - Fresnel's explanation of optical rotation and Half Shade & Biquartz polarimeters.

Dispersion Equation of motion of an electron in a radiation field, Lorentz theory of dispersion- normal and anomalous. Cauchy's formulae.

Scattering Scattering of radiation by a bound charge, Rayleigh scattering, blue of the sky; absorption.

Reference Books

[1] D.J. Griffiths, Introduction to Electrodynamics, Pearson Education, 2012.
[2] M.N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001.
[3] T.L. Chow, Introduction to Electromagnetic Theory, Jones & Bartlett Learning, 2006.
[4] M.A.W. Miah, Fundamentals of Electromagnetics, Tata McGraw Hill, 1982.
[5] R.S. Kshetrimayun, Electromagnetic Field Theory, Cengage Learning, 2012.
[6] Willian H. Hayt, Engineering Electromagnetics (8ed), McGraw Hill, 2012.
[7] G. Lehner, Electromagnetic Field Theory for Engineers and Physicists, Springer, 2010.
[8] P. Lorrain and D. Corson, Electromagnetic Fields and Waves, W.H.Freeman & Co.
[9] J.A. Edminster, Electromagnetics, Tata McGraw Hill, 2006.

[10] B. Guru and H. Hiziroglu, Electromagnetic Field Theory Fundamentals, Cambridge University Press, 2004.

Physics - Major 7 Lab : Electromagnetic Theory
60 Lectures

Experiments

1. To verify the law of Malus for plane polarised light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyse elliptically polarised Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves.
7. To study Polarisation and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarisation of light by reflection and determine the polarising angle for air-glass interface.
11. To verify the Stefan's law of radiation.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
13. Measurement of Planck's constant using black body radiation and photo-detector.
14. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
15. To determine work function of material of filament of directly heated vacuum diode.
16. To determine the Planck's constant using LEDs of at least 4 different colours.
17. To determine the wavelength of H-alpha emission line of Hydrogen atom.
18. To determine the ionisation potential of mercury.
19. To determine the value of e/m by (a) Magnetic focusing; or (b) Bar magnet.

Reference Books

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

[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.

[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.

[4] G. Lehner, Electromagnetic Field Theory for Engineers and Physicists, Springer, 2010.

Physics - Major 8 : Classical Dynamics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

Mathematical Preliminaries Matrices: Basic properties of matrices. Real symmetric, Hermitian, orthogonal and unitary matrices. Eigenvalue and Eigenvectors (degenerate and non-degenerate cases). Caley-Hamilton theorem. Diagonalisation of matrices.

Classical Mechanics of Point Particles Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalised coordinates and velocities. Calculus of variations: Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta and Hamiltonian. Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy.

Small Amplitude Oscillations Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N - 1) - identical springs.

Relativistic mechanics Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

Reference Books

[1] H.Goldstein, C.P. Poole and J.L. Safko, Classical Mechanics (3ed), Pearson Education, 2002.

[2] L.D. Landau and E.M. Lifshitz, Mechanics, Pergamon, 1976.

[3] J.D. Jackson, Classical Electrodynamics (3ed), Wiley, 1998.

[4] L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields (4ed), Elsevier, 2003.

[5] D.J. Griffiths, Introduction to Electrodynamics, Pearson Education, 2012.

[6] P.S. Joag and N.C. Rana, Classical Mechanics, McGraw Hall.

[7] R. Douglas Gregory, Classical Mechanics, Cambridge University Press, 2015.

[8] Dieter Strauch, Classical Mechanics: An Introduction, Springer, 2009.

[9] O.L. Delange and J. Pierrus, Solved Problems in Classical Mechanics, Oxford University Press, 2010.

Physics - Major 9 : Modern Physics and Quantum Mechanics (Credits: Theory-05, Tutorials-01) Theory: 75 Lectures

Empirical application to quantum ideas Planck's quantum hypothesis, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light. Photo-electric effect: Particle nature of radiation, photons. Compton scattering: Scattering of radiation as particles. Diffraction of matter particles: De Broglie wavelength and wave-particle duality. Experimental verification of de Broglie hypothesis: Davisson-Germer amd G.P. Thompson's experiment.

Atomic spectra: Ritz combination principle, Balmer and other series, Rutherford model. Bohr atomic model: Quantization of angular momentum, Bohr energies.

Atoms in Electric and Magnetic Fields: Space quantisation. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal and Anomalous Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Paschen Back and Stark Effect (Qualitative Discussion only).

Many electron atoms: Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Elements of quantum mechanics Particles as wave packets. Group and Phase velocities. Double split thought experiment with electrons. Probability. Wave amplitude and wave functions.

Position measurement - gamma ray microscope thought experiment; Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Impossibility of a particle following a trajectory from wave packets; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: application to virtual particles and range of an interaction.

Time dependent Schrodinger equation Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalisation. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Time independent Schrodinger equation Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

General discussion of bound states in an arbitrary potential Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy and uncertainty principle.

Quantum theory of hydrogen-like atoms Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d, ... shells.

Reference Books

[1] P.M. Mathews and K. Venkatesan, Text Book of Quantum Mechanics (2ed), McGraw Hill, 2010.
[2] Robert Eisberg and Robert Resnick, Quantum Mechanics (2ed), Wiley, 2002.
[3] Leonard I. Schiff, Quantum Mechanics (3ed), Tata McGraw Hill, 2010.
[4] G. Aruldhas, Quantum Mechanics (2ed), Prentice-Hall, 2002.
[5] Bruce Cameron Reed, Quantum Mechanics, Jones and Bartlett Learning, 2008.
[6] Arno Bohm, Quantum Mechanics: Foundations and Applications (3ed), Springer, 1993.
[7] D.A.B. Miller, Quantum Mechanics for Scientists and Engineers, Cambridge University Press, 2008.
[8] Eugen Merzbacher, Quantum Mechanics, John Wiley & Sons, 2004.
[9] D.J. Griffiths, Introduction to Quantum Mechanics (2ed), Pearson Education, 2005.
[10] Walter Greiner, Quantum Mechanics (4ed), Springer, 2001.

Semester VI

Physics - Major 10 : Solid State Physics (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Crystal Structure Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

Elementary Lattice Dynamics Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.

Magnetic Properties of Matter Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia and para magnetic domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Dielectric Properties of Materials Polarisation. Local Electric Field at an Atom. Depolarisation Field. Electric Susceptibility. Polarisability. Clausius Mosotti Equation. Classical Theory of Electric Polarisability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

Ferroelectric Properties of Materials Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Structure of Solids Different types of bondings, Free electron theory of metals, effective mass, drift current, Widemann Franz law.

Elementary band theory Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4 probe method) and Hall coefficient.

Superconductivity Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation).

Reference Books

[1] Charles Kittel, Introduction to Solid State Physics (8ed), Wiley India Pvt. Ltd, 2004.
[2] J.P. Srivastava, Elements of Solid State Physics (2ed), Prentice-Hall, 2006.
[3] Leonid V. Azaroff, Introduction to Solids, Tata Mc-Graw Hill, 2004.
[4] N.W. Ashcroft and N.D. Mermin, Solid State Physics, Cengage Learning, 1976.
[5] H. Ibach and H. Luth, Solid State Physics, Springer, 2009.
[6] Rita John, Solid State Physics, McGraw Hill, 2014.
[7] M. Ali Omar, Elementary Solid State Physics, Pearson India, 1999.
[8] M.A. Wahab, Solid State Physics, Narosa Publications, 2011.
[9] A. Sengupta and C.K. Sarkar, Introduction to Nano: Basics to Nanoscience and Nanotechnology, Springer, 2016.
[10] P.J. Collings and M. Hird, Solid State Physics, Introduction to Liquid Crystals, CRC Press, 1997.

Physics - Major 10 Lab : Solid State Physics
60 Lectures

Experiments

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the static dielectric constant of two dielectric materials.
5. To measure the Dielectric Constant of a dielectric Materials with frequency.
6. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR).
7. To determine the refractive index of a dielectric layer using SPR.
8. To study the PE Hysteresis loop of a Ferroelectric Crystal.
9. To draw the BH curve of Fe and determine energy loss from Hysteresis.
10. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 $^\circ$C) and to determine its band gap.

11. To determine the Hall coefficient of a semiconductor sample.
12. To study the dynamics of lattice vibrations via electrical simulation.

Reference Books

[1] B.L. Flint and H.T. Worsnop, Advanced Practical Physics for Students, Asia Publishing House, 1971.
[2] Michael Nelson and Jon M. Ogborn, Advanced Level Physics Practicals (4ed), Heinemann Educational Publishers, 1985.
[3] Indu Prakash and Ramakrishna, A Text Book of Practical Physics (11ed), Kitab Mahal, 2011.
[4] J.P. Srivastava, Elements of Solid State Physics (2ed), Prentice-Hall, 2006.

Physics - Major 11 : Statistical Mechanics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

Classical Statistics Statistical descriptions of system of particles, Macrostate and Microstate, Elementary Concept of Ensemble, Phase Space. Distribution of energy between macroscopic systems. Microcanonical ensemble, Postulate of Equal a-priori probabilities, Entropy and Thermodynamic Probability. Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox. Equivalence of microcanonical and canonical ensemble. Grand canonical ensemble. Application of ideal gas using grand canonical ensemble. Concept of chemical potential. Sackur Tetrode equation, Law of Equipartition of Energy(with proof), Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature.

Systems of Identical particles Collection of non-interacting identical particles. Classical approach and quantum approach: distinguishability and indistinguishability, Occupation number and MB distribution, Emergence of Boltzmann factor, Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only), Bosons and Fermions. Symmetric and Antisymmetric wave functions, State counting for Bosons and Fermions.

Application of Statistical Mechanics in thermodynamics

Conduction Conductivity, Diffusivity, Fourier equation for heat conduction.

Convection Importance in Atmospheric Science Adiabatic lapse rate.

Classical Theory of Radiation Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Newton's laws of cooling, Wien's Displacement law. Wien's Distribution Law. Saha's Ionisation Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

Quantum Theory of Radiation Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

Quantum Statistics

Bose-Einstein Statistics B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

Fermi-Dirac Statistics Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. Richardson Dushman equation. Dependence of Fermi Level with temperature.

Reference Books

[1] R.K. Pathria, Statistical Mechanics (2ed), Oxford University Press, 1996.
[2] F. Reif, Statistical Physics - Berkeley Physics Course, Tata McGraw-Hill, 2008.
[3] S. Lokanathan and R.S. Gambhir, Statistical and Thermal Physics, Prentice Hall, 1991.
[4] Francis W. Sears and Gerhard L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, 1986.
[5] Carl S. Helrich, Modern Thermodynamics with Statistical Mechanics, Springer, 2009.
[6] R.H. Swendsen, An Introduction to Statistical Mechanics and Thermodynamics, Oxford University Press, 2002.

Physics - Major 12 : Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

General Properties of Nuclei Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

Nuclear Models Liquid drop model approach, semi empirical mass formula and significance of its various terms, α and β nuclear stability from semi empirical mass formula, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

Radioactivity decay (a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) Beta decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission and kinematics, internal conversion.

Nuclear Reactions Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

Interaction of Nuclear Radiation with matter Energy loss due to ionisation (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

Detector for Nuclear Radiations Gas detectors: estimation of electric field, mobility of particle, for ionisation chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

Particle Accelerators Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

Particle physics Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

Reference Books

[1] Kenneth S. Krane, Introductory Nuclear Physics, Wiley India Pvt. Ltd., 2008.
[2] Bernard L. Cohen, Concepts of Nuclear Physics, Tata Mcgraw Hill, 1998.
[3] R.A. Dunlap, Introduction to the Physics of Nuclei and Particles, Thomson Asia, 2004.
[4] D.H. Perkins, Introduction to High Energy Physics, Cambridge Univ. Press.
[5] D.J. Griffith, Introduction to Elementary Particles, John Wiley & Sons.
[6] F. Halzen and A.D. Martin, Quarks and Leptons, Wiley India.
[7] K. Heyde, Basic Ideas and Concepts in Nuclear Physics – An Introductory Approach, IOP, 2004.
[8] G.F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2000.
[9] Syed Naeem Ahmed, Physics and Engineering of Radiation Detection, Academic Press, 2007.
[10] J.M. Blatt and V.F. Weisskopf, Theoretical Nuclear Physics, Dover, 1991.