UNIVERSITY OF GOUR BANGA

(Established Under West Bengal Act XXVI Of 2007)

CBCS SYLLABUS

For

B.Sc. PHYSICS HONOURS

TOTAL MARKS: 1300

TOTAL CREDIT: 140

2019

Scheme of CBCS Curriculum

1. Basic Courses Types under CBCS: In CBCS there are some basic types of courses relevant to the B.Sc. curricula have been described below.
2. Discipline Course (DC): A discipline specific core course.
3. Discipline Specific Elective Course (DSE): A discipline specific elective course which is specialized.
4. Generic Elective Course (GE): An inter-disciplinary elective course to be opted from a discipline other than ones main discipline(s) of choice (e.g., a course in a discipline other than in which honours has been taken).
5. Skill Enhancement Course (SEC): A discipline specific elective skill enhancement course.
6. Ability Enhancement Compulsory Course (AEC): These are courses. There are two of them. AEC-1 is Communicative English / Modern Indian Language (e.g.: Bengali, Urdu, Hindi.) & AEC-2 is Environmental Science.

		Core Papers	**Elective Papers**	**General Papers GE**	**Ability Enhancement Compulsory AEC**	**Skill Enhancement SEC**	**Credits**	**Marks**
1st year	Sem-I	DC1:Mathematical Physics-I (6) DC2:Mechanics(6)		GE1 (6)	ENVS(2)		20	200
	Sem-II	DC3: Electricity and Magnetism(6) DC4: Wave and Optics(6)		GE2 (6)	MIL(2)		20	200
2nd year	Sem-III	DC5: Mathematical Physics - II (6) DC6: Thermal Physics(6) DC7: Digital Systems and Application(6)		GE3 (6)			24	200
	Sem-IV	DC8 Mathematical Physics - III (6) DC9: Elements of Modern Physics (6) DC10: Quantum Mechanics and Apllications (6)		GE4 (6)			24	200
3rd year	Sem-V	DC11: Solid State Physics(6) DC12:Quantum Mechanics and Applications	DSE1: Advanced Mathematical Physics I(6) Or Nuclear and Particle Physics(6) DSE2: Classical Dynamics(6) Or Communication Electronics(6)			SEC1: Electrical circuits & Network Skills (2) Or Computational Physics Skills(2)	26	250
	Sem-VI	DC13: Electromagnetic Theory(6) DC14: Statistical Mechanics(6)	DSE3: Advanced Mathematical Physics II(6) Or Applied Dynamics(6) DSE4:Astronomy and Astrophysics(6) Or Nano-material and Applications(6)			SEC2: Renewable Energy & Energy harvesting (2) Or Basic Instrumentation Skills(2)	26	250
	Total						140	1300

Marks and question type distribution for Physics Honourse

No. of courses	Total credit	Total Marks	Division of marks of each courses					
			Full Marks for each courses	Internal Assessment(IA)		End Semester Examination(ESE)		
						Theoritical		Practical
				Attendance 4%	Cont. Evalu./Test 6%	Descriptive	MCQ	
14DC	$14 \times 6 = 84$	$14 \times 50 = 700$	50	10		25	Nil	15
04DSE	$04 \times 6 = 24$	$04 \times 50 = 200$	50(non-practical)	10		40	Nil	0
			50(practical)	10		25	Nil	15
O4GE	$04 \times 6 = 24$	$04 \times 50 = 200$	50(practical)	10		25	Nil	15
02SE	$02 \times 2 = 04$	$02 \times 50 = 100$	50	10		40	Nil	0
AEC-1 (ENVS)	$01 \times 2 = 02$	$01 \times 50 = 50$	50	10(Project)		Nil	40	0
AEC-2 (MIL)	$01 \times 2 = 02$	$01 \times 50 = 50$	50	10		Nil	40	0
Grand Total	140	1300						

Details Syllabi for Discipline Core Courses (Honours)

Semester-I:

Paper: DC1- Mathematical Physics-I

Mathematical Physics-I (Theory): DC1T **Credit-4**

Total Lecture-24

1. **Calculus:**
   (a) Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves.

   Approximation: Taylor and binomial series (statements only).

   (b) First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.
   (c) Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration .Constrained Maximization using Lagrange Multipliers.
2. **Vector Calculus:**
   (a) 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.

   (b) 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.
   (c) Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian.Notion of infinitesimal line, surface and volume elements. 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)
3. **Orthogonal Curvilinear Coordinates:**

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

4. **Dirac Delta function and its properties:**

(a) Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Mathematical Physics, Goswami, 1st edition, Cengage Learning
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Mathematical Physics-I (Practical):DC1P

Total Lecture-32 **Credit-2**

List of Practicals

1. Introduction and Overview

(a) Computer architecture and organization, memory and Input/output devices.

2. Basics of scientific computing

(a) Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

3. Errors and error Analysis.

(a) Truncation and round oerrors, Absolute and relative errors, Floating point computations.

4. Introduction to plotting graphs with Gnuplot (or some other GUI based free software like Grace, Origin etc.)

(a) Basic 2D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, exporting plots.

5. Introduction to programming in python:

(a) Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, le handling, iterables, compound statements, indentation in python, the if-else block, for and while loops, nested compound statements.

6. Programs

(a) Elementary calculations with different type of data e.g., area and volume of regular shapes using formulae. Creation and handling one dimensional array. Sum and average of a list of numbers stored in array, finding the largest and lowest number from a list, swapping two data in a list, sorting of numbers in an array using bubble sort, insertion sort method. Calculation of term value in a series and nding the other terms with a seed (value of particular term) and calculation of different quantities with series. Convergence and accuracy of series. Introduction of three dimensional array. Simple calculations of matrices e.g., addition, subtraction, multiplication.

(b) Curve fitting, Least square fit, Goodness of fit, standard deviation

i. Ohms law to calculate R
ii. Hooke's law to calculate spring constant

Note: A list of suggestive numerical problems will be circulated from time to time.

Referred Books:

- • Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K.D. Hu , 2015, O'Rielly A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T. Pang, 2nd Edn., 2006,Cambridge Univ. Press Computational Physics, Darren Walker, 1st Edn., 2015, Scientic International Pvt. Ltd.

Paper: DC2 -Mechanics

Mechanics (Theory): DC2T **Credit-4**

Total Lecture-24

1. Fundamentals of Dynamics

(a) Review of Newton's Laws: Mechanistic view of the Universe. Concepts of Inertial frames, force and mass. Solution of the equations of motion (E.O.M.) in simple force fields in one, two and three dimensions using Cartesian, cylindrical polar and spherical polar coordinate systems.
(b) Dynamics of systems of particles: Difficulty of solving the E.O.M. for systems of particles. Newton's third Law. External and Internal forces. Momentum and Angular Momentum of a system. Torque acting on a system. Conservation of Linear and Angular Momentum. Centre of mass and its properties. Two-body problem.
(c) Variable- mass system: motion of rocket.

2. Work and Energy

(a) Work - Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field - concept of Potential Energy. Other equivalent definitions of a Conservative Force. Conservation of Energy.
(b) Qualitative study of one dimensional motion from potential energy curves. Stable and Unstable equilibrium.
(c) Energy of a system of particles.

3. Gravitation and Central Force Motion

(a) Central Force. Reduction of the two body central force problem to a one-body problem. Setting up the E.O.M. in plane polar coordinates.
(b) Differential equation for the path. Motion under an Inverse-square force. Newton's Law of Gravitation. Inertial and gravitational mass. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).
(c) Gravitational potential energy. Potential and field due to spherical shell and solid sphere.

4. Non-Inertial Systems

(a) Galilean transformations and Galilean invariance.
(b) Non-inertial frames and idea of fictitious forces. E.O.M with respect to a uniformly accelerating frame. E.O.M with respect to a uniformly rotating frame - Centrifugal and Corioli's forces. Laws of Physics in a laboratory on the surface of the earth.

5. Rotational Dynamics

(a) The Rigid Body: Constraints defining the rigid body. Degrees of freedom for a rigid body;
(b) Relation between Angular momentum and Angular Velocity - Moment of Inertia Tensor. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.
(c) E.O.M for rotation about a fixed axis.
(d) Principal Axes transformation. Transformation to a body fixed frame. E.O.M for the rigid body with one

point fixed (Euler's equations of motion). General motion of a rigid body - translation plus rotation. Kinetic energy of rotation.

6. Elasticity : Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Bending of a beam . Internal bending moment. Elastic potential energy.

7. Fluid Motion

(a) Kinematics of Moving Fluids: Idea of compressible and incompressible fluids, Equation of continuity; streamline and turbulent flow, Reynold's number. Euler's Equation. The special case of fluid statics $\vec{F} = \nabla p$: Simple applications (e.g: Pascal's law and Archimedes principle).
(b) Poiseuille's equation for Flow of a viscous Liquid through a Capillary Tube.

Reference Books

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw- Hill.
- Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley. Analytical Me- chanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole. Additional Books for Reference
- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000 University Physics.
- F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

Mechanics: DC2P **Credit-2**

Total Lecture-32

List of Practicals

1. To determine the height of a building using a Sextant.
2. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.
3. To determine the Moment of Inertia of a regular shaped body.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Young's Modulus of the material of a beam the Method of Flexure.
6. To determine the Modulus of Rigidity of the material of a Wire by Statical method.
7. To determine the Young's modulus of the material of a wire by Searle's method.
8. To determine the value of g using Bar Pendulum.
9. To determine the value of g using Kater's Pendulum

General Topic

1. Discussion on random errors in observations.
2. Measurements of length (or diameter) using slide callipers, screw gauge and travelling microscope.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal.
- Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
- Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

Semester-II:

Paper: DC3- Electricity and Magnetism **Credits: 4**

Electricity and Magnetism (Theory): DC3T

Total Lecture-24

1. Electrostatic Field

(a) Coulombs law and Principle of superposition leading to the definition of Electrostatic Field and Field lines.
(b) Divergence of the Electrostatic field. Flux, Gauss's theorem of electrostatics. Applications of Gauss theorem to and Electric field due to charge configurations with spherical, cylindrical and planar symmetry.
(c) Curl of the Electrostatic Field and its conservative nature. Electric potential. Potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.
(d) Laplace's and Poisson equations. Uniqueness Theorems. Method of Images and its application to: (1) Plane In finite Sheet and (2) Sphere.
(e) Conductors: Electric field and charge density inside and on the surface of a conductor. Conductors in an electrostatic field. Force per unit area on the surface. Capacitance of a conductor. Capacitance an isolated spherical conductor. Parallel plate condenser.
(f) Electrostatic energy of system of charges. Electrostatic energy of a charged sphere.
(g) Energy per unit volume in electrostatic field.

2. Dielectric properties of matter

(a) Electric potential and field due to an electric dipole. Electric dipole moment. Force and torque on a dipole.
(b) Electric Fields inside matter: Electric Polarization. Bound charges. Displacement vector. Relations between E, P and D. Gauss's theorem in dielectrics. Linear Dielectric medium. Electric Susceptibility and Permittivity. Capacitor (parallel plate, spherical, cylindrical) with dielectric.

3. The Magnetostatic Field

(a) Biot-Savart's law. Force on a moving point charge due to a magnetic field: Lorentz force law. Application of Biot-Savart's law to determine the magnetic field of a straight conductor, circular coil. Force between two straight current carrying wires.
(b) Divergence of the magnetic field - its solenoidal nature. Magnetic vector potential.
(c) Curl of the magnetic field. Ampere's circuital law and its application to
(1) Infinite straight wire,
(2) Infinite planar surface current,
(3) Solenoid.

4. Magnetic properties of matter.

(a) Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole in a uniform magnetic field.
(b) Magnetization. Bound currents. The magnetic intensity - H. Relation between B, H and M. Linear media. Magnetic Susceptibility and Permeability. Brief introduction of dia-, para- and ferro-magnetic materials. B-H curve and hysteresis.

5. Electro-magnetic induction

(a) Ohms law and definition of E.M.F. Faraday's laws of electromagnetic induction, Lenz's law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Introduction to Maxwell's Equations. Charge conservation. Displacement current and resurrection of Equation of Continuity.
(b) Energy stored in magnetic field.

6. Electrical circuits: AC Circuits: Kirchhoff 's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dis- sipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit

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

Reference Books

- Introduction to Electrodynamics, D.J. Gri ths, 3rd Edn., 1998, Benjamin Cummings.
- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choud- hury, 2012, Tata McGraw Hill.
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Edu- cation.
- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education.
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Ellectricity and Magnetism, D.Chattopadhyay and P.C.Rakshit, New Cen- tral Book Agency, 2011.
- Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Electricity and Magnetism (Practical) : DC3P **Credit-2**

Total Lecture-32

List of Practical

1. To study the I -V characteristics of a series RC Circuit with AC source.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine the resistance of a galvanometer using Thomson's method.
5. Measurement of magnetic field strength B and its variation with pole gap using Search coil.
6. To verify the Thevenin and Norton theorems.
7. To verify the Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson's bridge.
9. 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.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.

General Topics

1. Using a Multi-meter for measuring (a) Resistances, (b) AC and DC Volt- ages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses should be taught in the Practical classes as a general prerequisite.

Note: For the sake of brevity, details of ballistic galvanometer have been omitted from the theory course. Some part of the theory may be needed for the experiments. This should be covered as part of Practical.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
- ALaboratoryManualofPhysicsforundergraduateclasses,D.P.Khandelwal, 1985, Vani Pub.

Paper: DC4-Waves and Optics

Waves and Optics (Theory)- DC4T **Credit-4**

Total Lecture-24

1. Oscillations

(a) SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

2. Superposition of Harmonic Oscillations

(a) Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.
(b) Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

3. Wave motion

. (a) Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Traveling) Waves. Wave Equation. Particle and Wave Velocities. Di erential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

. (b) Water Waves: Ripple and Gravity Waves

4. Velocity of Waves

(a) (a) Velocity of Transverse Vibrations of Stretched Strings.

(b) (b) Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's For- mula for Velocity of Sound. Laplace's Correction.

5. Superposition of Harmonic Waves

- (a) Standing (Stationary) Waves in a String: Fixed and Free Ends. An- alytical Treatment. Changes with respect to Position and Time. En- ergy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment.

- (b) Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.

- (c) Superposition of N Harmonic Waves. Phase and Group Velocities.

6. Wave optics

(a) Electromagnetic nature of light. De nition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

7. Interference

(a) Division of amplitude and wave front. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reaction: 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.

8. Interferometers

. (a) Michelson Interferometer-(1) Idea of form of fringes (No theory re- quired), (2) Determination of Wavelength, (3) Wavelength Di erence, (4) Refractive Index, and (5) Visibility of Fringes.

. (b) Fabry-Perot interferometer.

9. Di raction and Holography

(c) (a) Fraunhofer di raction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Di raction grating. Re- solving power of grating.

(d) (b) Fresnel Di raction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fres- nel's Integral, Fresnel di raction pattern of a straight edge, a slit and a wire.

(e) (c) Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

Reference Books

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw- Hill.
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
- Optics, 4th Edn., Eugene Hecht, Pearson Education Limited, 2014.
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
- A textbook of Optics; N Subramanyam, B. Lal and M.N.Avadhanulu; S.Chand. Publishing.

Waves and Optics (Practical): DC4P Credits: 2

Total Lecture-32

List of Practicals

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To investigate the motion of coupled oscillators.
3. Familiarization with: Schuster`s focusing; determination of angle of prism.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
6. To determine the wavelength of sodium source using Michelson's interferometer.
7. To determine wavelength of sodium light using Fresnel Biprism.
8. To determine wavelength of sodium light using Newton's Rings.
9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10. To determine dispersive power and resolving power of a plane diffraction grating

General Topics

1. In the practical classes, students should be thoroughly familiarized with Schuster's focusing for their general pro ciency with spectrometers.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- ALaboratoryManualofPhysicsforundergraduateclasses,D.P.Khandelwal, 1985, Vani Pub.

Semester - III:

Paper: DC5T Mathematical Physics - II

Mathematical Physics - II (Theory) Credits: 4

Total Lecture-24

1. 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. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

2. Frobenius Method and Special Functions

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x))and Orthogonality.

3. Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

4. Variational calculus in physics : Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian formulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.

5. Partial Differential Equations : Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Reference Books

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Else- vier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.

Mathematical Physics – II (Practical) :DC5P **Credits: 2**

Total Lecture-32

List of Practicals

1. Introduction to Numerical computation using numpy and scipy.

Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of differential equations.

2. Solution of Linear system of equations by Gauss elimination method and Gauss Seidel method.
3. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen value problems (a) Solution of mesh equations of electric circuits (3 meshes) (b) Solution of coupled spring mass systems (3 masses)
4. Generation of Special functions using User defined functions(a) Generating and plotting Legendre Polynomials Generating and plot- ting Bessel function (Make use of generating function and recursion formula).
5. Root finding: Bisection and Newton-Raphson method.
6. Interpolation by Lagranges method.
7. Numerical differentiation - forward and backward difference formulae.
8. Numerical integration - trapezoidal and simpsons rule.
9. Solution of ODE: First order Differential equation - Euler's method.
10. Basic 3D graph plotting - plotting functions and data les, parametric plots, Surface and contour plots.

Note: A list of suggestive numerical problems may be circulated from time to time.

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
- Numpy beginners guide, Idris Alba, 2015, Packt Publishing.
- Computational Physics, D.Walker, 1st Edn., 2015, Scienti c International Pvt. Ltd.
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scienti c and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernandez. 2014 Springer.

Paper: DC6- Thermal Physics

Thermal Physics (Theory): DC6T Credits: 4

Total Lecture-24

1. Introduction to Thermodynamics

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

(b) 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 & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence.

(c) Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(d) 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 Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

2. Thermodynamic Potentials

(a) 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 demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

(b) Maxwell's Thermodynamic Relations

(c) 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 coe cient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

3. Kinetic Theory of Gases

(a) 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). Speci c heats of Gases.

(b) Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

(c) Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 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 Correspond- ing 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 E ect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

4. Conduction of Heat

(a) Thermal conductivity, diffusivity. Fourier's equation for heat conduction its solution for rectilinear flow of heat.

Reference Books

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publica- tions.

Thermal Physics (Practical): DC6P Credits: 2

Total Lecture-32

List of Practicals

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Glass in the form of tube.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and
   a. Charlton's disc method.

   To determine the Temperature Coefficient of Resistance by Platinum Resistance
   b. Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range using Null Method to determine Neutral Temperature

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khan- delwal, 1985, Vani Pub.

Paper: DC7- Digital Systems and Applications

Digital Systems and Applications (Theory):DC7T Credits: 4

Total Lecture-24

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

2. Digital Circuits : 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.

3. 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.

4. Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

5. Circuits:

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 condi- tions in JK Flip-Flop. M/S JK Flip-Flop.

6. Timers ICs: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

7. 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).

8. Counters (4 bits) : Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

9.Computer Organization

(a) Input/Output Devices. Data storage (idea of RAM and ROM). Com- puter memory. Memory organization & addressing. Memory Inter- facing. Memory Map.

Reference Book

- Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.

- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
- MicroprocessorArchitectureProgramming&applicationswith8085,2002, R.S. Goankar, Prentice Hall.

Digital Systems and Applications (Practical): DC7P Credits: 2

Total Lecture-32

List of Practicals

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.
2. To design a combinational logic system for a specified Truth Table.
3. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
4. To minimize a given logic circuit.
5. Half Adder, Full Adder and 4-bit binary Adder.
6. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
7. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
8. To build JK Master-slave flip-flop using Flip-Flop ICs
9. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
10. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

Reference Book

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

Semester-IV

Paper: DC8T -Mathematical Physics – III

Mathematical Physics – III (Theory) Credits: 4

Total Lecture-24

1. Complex Analysis **:** Brief Revision of Complex Numbers. and their Graphical Representation. Euler's formula, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving De nite Integrals.

2. Integrals Transforms : Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

3. Introduction to probability : Independent random variables: Sample space and Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance.

4. Special theory of Relativity

(a) Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity. Relativistic Dynamics. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Transformation of Energy and Momentum.

(b) Relativity in Four Vector Notation: Four-vectors, Lorentz Transformation and Invariant interval, Space-time diagrams. Proper time and Proper velocity. Relativistic energy and momentum - Four momentum. Conservation of four momentum and applications to collisions. Minkowski Force.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications.
- Complex Variables, A.S.Fokas & M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press.
- Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press.
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill.
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett.
- Relativity - The Special and General Theory, A. Einstein, Methuen & Co. Ltd., 1920.

- Introduction to Special Relativity, R. Resnick, 2010, John Wiley and Sons.
- Introduction to Electrodynamics, D.J. Gri ths, 3rd Ed., 1998, Benjamin Cummings, 1991.

Mathematical Physics - III (Practical) : DC8P Credits: 2

Total Lecture-32

List of Practicals

1. Solution of ODE/PDE:
   a) Initial value problem: Modified-Euler and Runge-Kutta second order fourth order methods.
   b) Boundary value problems: Finite difference method with fixed step size. Application to simple physical problems.
2. Dirac Delta function

   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{(x-2)^2}{2\sigma^2}}(x+3)dx$ for $x = 1, 0.1, 0.01$ and show that it t ends to 5.

3. Fourier series
   (a) Program to sum $\sum_{n=0}^{\infty}(0.2)^n$

   (b) Evaluate the fourier coefficients of a given periodic function (square wave).

4. Frobenius method and special functions.
   (a) $\int P_n(\mu)P_m(\mu)d\mu = \delta_{nm}$
   (b) Plot $P_n(x)$, $j_v(x)$
   c) show recursion relation.

5. Evaluation of trigonometric functions e.g. sinθ. Given Bessel's function at N points find its value at an intermediate point.
6. Complex analysis:
   (a) Integrate $\int \left(\frac{sinx}{x}\right)dx$ numerically and check with computer integration.
   (b) Root finding:
      i. Compute the nth roots of unity for $n = 2, 3\ and\ 4$.
      ii. Find the two square roots of −5 + 12i.
7. Integral transform: FT of e^{-x^2}
8. Introduction to OCTAVE.

Note:A list of suggestive numerical problems may be circulated from time to time.

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.

- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scienti c and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernanndez. 2014 Springer ISBN: 978-3319067896.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
- https://web.stanford.edu/ boyd/ee102/laplace_ckts.pdf.
- https://ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf.

Paper: DC9- Elements of Modern Physics

Elements of Modern Physics (Theory) DC9T **Credits: 4**

Total Lecture-24

1. Unit 1

(a) Blackbody Radiation, Planck's quantum, Planck's constant. Photo- electric effect and Compton scattering - light as a collection of pho- tons. Davisson-Germer experiment. De- Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes.

(b) Two-Slit experiment with photons and electrons. Linear superposition principle as a consequence.

(c) Position measurement- gamma ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations). Impossibility of a particle following a trajectory.

2. Unit 2

(a) Postulates of Quantum Mechanics: States as normalized vectors (normalized wave functions). Dynamical variables as linear Hermitian operators. Predictions of quantum mechanics from solving the eigenvalue equation for the observables. Illustration using two and three level systems. Expectation values of observables.

(b) Time evolution: Schrodinger equation for non-relativistic particles. Stationary states. Solution of Schrodinger's equation using expansion in stationary states. Time evolution of expectation values.

(c) Application to one dimensional systems. Particle moving in one dimension: Position, Momentum and Energy operators. Probability and probability current densities in one dimension. Boundary conditions on wave functions. Ehrenfest theorem. Particle in a one dimensional infinitely rigid box: energy eigenvalues and eigen functions, normalization. Quantum dot. Quantum mechanical scattering and tunneling in one dimension across a step potential & rectangular potential barrier.

(d) Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity. Heisenberg's uncertainty relation for a pair of incompatible observables. Complete and incomplete measurements - degeneracy. Ilustration of the ideas using the Angular momentum operators.

3. Unit 3

(a) 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.

(b) Nature of nuclear force, NZ graph.

(c) Nuclear Models: Liquid Drop model. semi-empirical mass formula and binding energy. Nuclear Shell Model. Magic numbers.

4. Unit 4

(a) Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

(b) Fission and fusion: mass de cit, relativity and generation of energy. Fission - nature of fragments and emission of neutrons. Nuclear re- actor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions)

(c) Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He- Ne Laser. Basic lasing.

Reference Books

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Primer of Quantum Mechanics; M. Chester; John Wiley & Sons, 1987.
- Introduction to Quantum Mechanics, David J. Gri th, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill.
- Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan[SEP]Additional Books for Reference
- Modern Physics, J.R. Taylor, C.D. Za ratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Nuclear Physics; S.N.Ghosal; S. Chand Publishing.
- Laser Physics and Spectroscopy, P.N.Ghosh, Levant Books, India, 2016.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill.

Elements of Modern Physics (Practical) :DC9P **Credits: 2**

Total Lecture-32

List of Practicals

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8. To determine the wavelength of laser source using diffraction of single slit.
9. To determine the wavelength of laser source using diffraction of double slits.
10. To determine (1) wavelength and (2) angular spread of He-Ne or any type of laser source using plane diffraction grating

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal.

Paper: DC10: Analog Systems and Applications

Analog Systems and Applications (Theory) DC10T: Credits: 4

Total Lecture-24

1. Semiconductor Diodes

(a) P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Re- verse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

- Two-terminal Devices and their Applications.

(a) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C- filter.
(b) Zener Diode and Voltage Regulation. Principle and structure of
(1) LEDs,
(2) Photodiode and
(3) Solar Cell.

3. Bipolar Junction transistors n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations be- tween α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cuto fazand Saturation Regions. SEP

4. Field Effect transistors Basic principle of operations only.

6. Amplifiers

(a) 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. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier.

(b) Coupled amplifie: Two stage RC-coupled amplifie.

(c) Feedback in amplifier: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

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

(e) 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.

(f) Applications of Op-Amps: Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integra- tor, (6) Log amplifie, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear (1) inverting and non-inverting comparators, (2) Schmidt triggers.

(g) Conversion: Resistive network (Weighted and R-2R Ladder). Accu- racy and Resolution. A/D Conversion (successive approximation)

Reference Books

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI.
- Learning Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
- Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

Analog Systems and Applications (Practical): DC10P **Credits: 2**

Total Lecture-32

List of Practicals

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
7. To study the frequency response of voltage gain of a RC-coupled(single stage) transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
10 To design inverting amplifier using Op-amp (741,351) and study its frequency response
11. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response

12. To add two dc voltages using Op-amp in inverting and non-inverting mode
13. To design a precision Differential amplifier of given I/O specification using Op-amp.
14. To investigate the use of an op-amp as an Integrator.
15 To investigate the use of an op-amp as a Differentiator.

Reference Books

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill. Electronic Devices & circuit Theory, R.L. Boylestad & L.D.
- Nashelsky, 2009, Pearson.

Semester - V:

Paper: DC11: Quantum Mechanics and Applications

Quantum Mechanics and Applications (Theory): DC11T: **Credits: 4**

Total Lecture-24

1. Schrodinger Equation

(a) Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wave function. Position-Momentum un-certainty.

2. General discussion of bound states in an arbitrary potential

(a) Continuity of wave function, boundary condition and emergence of discrete energy levels. Application to one-dimensional problem - square well potential.

3. Quantum mechanics of simple harmonic oscillator.

(a) Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms of Hermite polynomials (Solution to Hermite di erential equation may be assumed). Ground state, zero point energy & uncertainty principle.

4. Quantum theory of hydrogen-like atoms

(a) Reduction of a two body problem to a one body problem. The time independent Schrodinger equation for a particle moving under a central force - the Schrodinger equation in spherical polar coordinates. Separation

of variables. Angular equation and orbital angular momentum. Spherical Harmonics (Solution to Legendre differential equation may be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for the radial wavefunctions (Solution to Laguerre differential equation may be assumed). Shapes of the probability densities for ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d,shells.

5. Generalized Angular Momenta and Spin.

(a) Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. Gyromagnetic Ratio and Bohr Magneton and the g - factor. Energy associated with a magnetic dipole placed in magnetic field. Larmor's Theorem. Stern-Gerlach Experiment.

(b) Addition of angular momenta - statement only. Restriction of eigen- values from $|j_1 - j_2|$ to $|j_1 + j_2|$.

6. Spectra of Hydrogen atom and its ne structure

(a) Formula for first order nondegenerate perturbative correction to the eigenvalue - statement only.

(b) Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term.

(c) Fine structure of the hydrogen atom spectrum

7. Atoms in Electric & Magnetic Fields

(a) Zeeman Effect: Normal and Anomalous Zeeman Effect (Formula for first order perturbative correction to the eigenvalue to be assumed).

(b) Paschen Back e ect & Stark e ects (Qualitative Discussion only).

8. Many electron atoms

(a) Identical particles. Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's Rule. Periodic table.

(b) Fine structure splitting. L-S and J-J coupling scheme. Spectral No- tations for Atomic States and Term symbols. Spectra of Alkali Atoms (Na etc.).

Reference Books

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Introduction to Quantum Mechanics, D.J. Gri th, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Leonard I. Schi , 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cam- bridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Quantum Mechanics and Applications (Practical): DC11P **Credits: 2**

List of Practical

Total Lecture-32

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}(V(r) - E), V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain energy eigen values and plot the corresponding wavefunction. Remember that the ground state energy is -13.6 eV. Take$= 3.795(\text{eV}\mathring{\text{A}})$ and $m = 0.511 \times 10^6 \left(\frac{eV}{c^2}\right)$. nm may be used instead of Angstrom,]

2. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}(V(r) - E)$$

for the screened coulomb potential.

$$V(r) = -\frac{e^2}{r}\exp(-\frac{r}{a})$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $\text{e} = 3.795\ \text{eVÅ}^{2}$, $\text{m} = 0.511 \times 10^{6\ \text{eV}}$, and $\text{a} = 3\text{Å}, 5\text{Å}, 7\text{Å}$. In these units $\hbar\text{c} = 1973\ \text{eV Å}$. The ground state energy is expected to be above -12 eV in all three cases. [nm may be used instead of Å - make necessary conversions]

3. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}(V(r) - E)$$

for anharmonic oscillator potential

$$V(r) = \frac{1}{2}k^2 + \frac{1}{3}b\,r^3$$

for the ground state energy (in Mev) of particle to an accuracy of three

significant digits. Also, plot the corresponding wave function. significant digits. Also, plot the corresponding wave function. Choose

m $= 940\,\frac{\text{MeV}}{c^2}$, k = 100 Mevfm^{-2} b = 0,10,30 Mevfm^{-3}. In these

units, $\hbar c$= 197.3 M eV , f m. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4.

Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)\,u(r), \qquad A(r) = \frac{2\mu}{\hbar^2}\,(V(r) - E)$$

where μ is the reduced mass of the two-atom system for the Morse potential:

$$V(r) = D\left(e^{-2\alpha r'} - e^{-\alpha r'}\right), \qquad r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take $m = 940 \times 10^6\ \frac{eV}{c^2}$, $D = 0.755501\ eV$, $\alpha = 1.44$, $r_0 = 0.131349$ Å

[nm may be used instead of the unit Å- make necessary conversions]

Reference Books

- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cam- bridge Univ.Press
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez. 2014, Springer.

Paper: DC12 Solid State Physics

Solid State Physics (Theory) DC12T **Credits: 4**

Total Lecture-24

1. Crystal Structure

(a) 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.

2. Elementary Lattice Dynamics

(a) 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

3. Magnetic Properties of Matter

(a) Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia- and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferro-magnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

4. Dielectric Properties of Materials

(a) Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equa- tion. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

5. Ferroelectric Properties of Materials

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

6. Elementary band theory

(a) 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) & Hall coefficient.

7. Superconductivity

(a) 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

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice- Hall of India
- Introduction to Solids, Leonid V. Azaro , 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics and Electronics, A.B.Gupta and N.Islam, Books and Allied (P) Ltd.
- Quantum Mechanics, Statistical Machanics and Solid State Physics, 2010, S.Chand & Company.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Solid State Physics (Practical): DC12P

Total Lecture-32

List of Practicals

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 Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice- Hall of India.

Semester - VI:

Paper: DC13: Electromagnetic Theory

Electromagnetic Theory (Theory) -DC13T **Credits: 4**

Total Lecture-24

1. Maxwell Equations

(a) Review of Maxwell's equations. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

2. EM Wave Propagation in Unbounded Media

(a) Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

3. EM Wave in Bounded Media

(a) Boundary conditions at a plane interface between two media. Refection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal refraction, evanescent waves. Metallic reaction (normal Incidence).

4. Electromagnetic origin of Wave Optics

7. (a) Kirchhoff 's Integral Theorem, Fresnel-Kirchhoff 's Integral formula. (Qualitative discussion only) L SEP

8. (b) Description of Linear, Circular and Elliptical Polarization. Origin of Double-Refraction: Propagation of E.M. Waves in Anisotropic Me- dia. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. L SEP

5. Polarization in uniaxial crystals

(a) Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Phase Retardation Plates: Quarter-

Wave and Half-Wave Plates. Production & analysis of polarized light. Babinet Compensator and its Uses.

6. Rotatory polarization.

(a) Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade and biquartz polarimeters.

Reference Books

- Introduction to Electrodynamics, D.J. Gri ths, 3rd Ed., 1998, Benjamin Cummings.
- Optics, E. Hecht, 2016, Pearson.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic eld Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic eld theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press

Electromagnetic Theory (Practical): DC13P **Credits: 2**

Total Lecture-32

List of Practicals

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
5. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
6. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Paper: DC14 :Statistical Mechanics

Statistical Mechanics (Theory) : DC14T **Credits: 4**

Total Lecture-24

1. Classical Statistical Mechanics

(a) Macrostate & Microstate, Elementary Concept of Ensemble and Ergodic Hypothesis. Phase Space.

(b) Microcanonical ensemble, Postulate of Equal a-priori probabilities. Boltzmann hypothesis: Entropy and Thermodynamic Probability.

(c) Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox.

(d) Law of Equipartition of Energy(with proof) - Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature.

(e) Grand canonical ensemble and chemical potential.

2. Classical Theory of Radiation

(a) Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff 's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

3. Quantum Theory of Radiation

(a) 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.

4. Bose-Einstein Statistics:

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

5. Fermi-Dirac Statistics:

(a) Fermi-Dirac Distribution Law. Thermodynamic functions of a Com- pletely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals.

Reference Books

9. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.

10. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw- Hill.

11. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.

12. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Fran- cis W. Sears and Gerhard L. Salinger, 1986, Narosa.

13. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.

14. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.

15. Statistical Mechanics - an elementary outline, A. Lahiri, 2008, Universities Press.

Statistical Mechanics (Practical):DC14P **Credits: 2**

Total Lecture-32

List of Practicals

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   (a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   (b) Study of transient behavior of the system (approach to equilibrium)
   (c) Relationship of large N and the arrow of time
   (d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   (e) Computation and study of mean molecular speed and its dependence on particle mass
   (f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function Z (β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics:

(a) Study of how Z (β), average energy ⟨E⟩, energy fluctuation ΔE, specific heat at constant volume C_V, depend upon the temperature, total number of particles N and the spectrum of single particle states.

(b) Ratios of occupation numbers of various states for the systems considered above

(c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Raleigh- Jeans Law at high temperature and low temperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5. Plot the following functions with energy at different temperatures (a) Maxwell-Boltzmann distribution (b) Fermi-Dirac distribution(c) Bose-Einstein distribution

Reference Books

16. Elementary Numerical Analysis, K.E.Atkinson, 3 rd Edn . 20 07 , Wiley India Edition

17. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

18. Introduction to Modern Statistical Mechanics, D. Chandler, Oxford Uni- versity Press, 1987

19. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Fran- cis W. Sears and Gerhard L. Salinger, 1986, Narosa.

20. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

21. StatisticalandThermalPhysicswithcomputerapplications,HarveyGould and Jan Tobochnik, Princeton University Press, 2010.

22. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scienti c and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez. 2014 Springer ISBN: 978-3319067896

Syllabi for Discipline Specific Elective Courses (Honours)

Paper: DSEA1 :Advanced Mathematical Methods - I

Advanced Mathematical Methods - I - (Theory): DSEA1T **Credits: 5 (+1 for Tutorial)**

Total Lecture-56

1. Preliminaries

11. Set, Logical Connectivities, Proof and Function: Notion of set and basic set algebra (Venn diagram should not be used to do set algebra). Definition of OR, AND, NOT and IF-THEN. Example of direct proof, proof by contradiction. Vacuous proof (as for example null set is a subset of every set).
12. Definition of function (distinction should be made between function f and the value of the function f (x) of function f at x). For real or complex valued function definition of zeros of a function and Zero function. Equality of functions. Example of function. Constant function (Mention the fact that function is neither a dependence nor an expression), Dirichlet function (Mention the fact that it does not have any graph) and other examples of standard real and complex valued functions.
13. Mathematical Induction (Mention that it requires proof) and its applications.

2. Real Numbers and Complex Numbers

(a) Axiomatic description of real number, Few applications of axioms to show its power (as for example prove $a.0 = 0, a(-b) = -(ab)\ 1 > 0$,etc.). Distinction between real or finite number and infinity and also between undefined quantity (as for example $a/0$) and infinity. Complex numbers (Mention the fact that they are two dimensional vectors as Real numbers are one dimensional vectors and unlike real numbers complex numbers do not admit ordering and finally beyond complex number there is only one infinity not two).

(b) Sequence, Series and Power Series: Definition of sequence and series (Mention the fact that sums in the series are not real sum but limit of finite sums; they actually mimic some of the properties of actual sum). Limit superior and Limit inferior of a sequence. Convergence of a sequence (Stress should be given on $\varepsilon - N$ definition of convergence and show proof of few elementary sequences directly from $\varepsilon - N$ definition), Power series, Example of power series, Infinite G.P. series, Uniform convergence of power series, example and Weierstrass M-test (Also mention the fact for uniform convergence of a power series we can differentiate or integrate a power series term by term), Zero power series and equality of two power series. Radius of convergence of a power series mentioning its relation with the Limit Superior of its coefficients.

3. Basics of Calculus

(a) Differential Calculus in one variable: Definition of limit (Stress should be given on epsilon-delta definition and show proof of some standard limits using epsilon-delta definition, also mention

the fact that limiting value of a function when x approaches a does not depend at all on f (a)). Definition of Continuity (Mention the fact that if function is continuous at a and f (a) > 0, then there exists an open interval around a where function is entirely positive). Definition of derivative (Emphasis given on the first principle and mention the fact that for any arbitrary curve derivative actually defines tangent i.e. we de ne derivative via tangent). Rolle's Theorem and Mean value Theorem of Differential Calculus (with proof) and its application.

(b) Integral Calculus in one variable: Definition of Anti derivative and Riemann (or definite) integral. Fundamental Theorem of Integral Calculus (With proof, mention the fact that although they are different, but we use one of them to calculate another). Riemann integral defines area enclosed by arbitrary curve. Mention sufficient conditions for integrability (as for example continuity or piece-wise continuity or even when set of points of discontinuity is countable, the function is integrable). Mean Value Theorem of Integral Calculus (with proof) and its applications.

4. Linear Algebra.

a. Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces over Real and Complex Fields. Subspaces. Homomorphism and Isomorphism of Vector Spaces. Lin- ear Independence and Dependence of Vectors. Completeness of a set of vectors. Basis of a vector space. Replacement theorem - unique- ness of cardinality of different bases - Dimensions of a Vector Space. Change of basis. Isomorphism of every n - dimensional vector space with C^n - basis dependence of this isomorphism.

b. Inner products Space. Norm (defined in terms of inner product). Orthogonality. Orthogonal and Orthonormal sets. Orthonormal basis. Change of orthonormal basis. Gram-Schmidt orthogonalization - proof that an orthonormal basis will always exist. Schwarz inequality. Linear functionals on a vector space. Addition and Multiplication by scalars on linear functionals. Dual Space. Bra and Ket vectors and the Bra-Ket notation. Dual Basis. Construction of bra from ket and vice-versa.

c. Linear Transformations and Linear Operators. Consequences of linearity: Specification of the action of an operator on a basis defines the action on the whole space - Representation of Linear Operators by Matrices. Transformation of representations under change of basis. Algebra of Linear Operators. Singular and Non-singular operators. The Adjoint or Hermitian conjugate of an operator. Hermitian, Orthogonal and Unitary operators. Projection operators.

d. Eigenvalues and Eigenvectors of an operator. Degeneracy and Eigen spaces. Algebraic and Geometric multiplicity of eigenvalues. Diagonalization and Diagonalizability. Normal operators. Eigen properties of Hermitian and Unitary operators. Commuting operators and its relation to simultaneous diagonalizability. Complete sets of commuting operators.

e. Tensor Products of Inner product spaces. Tensor products of vectors and operators. Extensions of operators to product spaces.

Reference Books

- Calculus Volume I and II, Tom Apostol, John Wiley and Sons Inc.
- Bartle and Sherbert, Introduction to Real Analysis, Third edition, Wiley- India
- Complex Analysis, V.L Ahlfors, McGraw-Hill Inc.
- Finite Dimensional Vector Spaces, P. R.Halmos, Springer.

- Introduction To Matrices And Linear Transformations, D.T. Finkbeiner, Courier Corporation.
- Linear Algebra, S. Lipschutz and M.L.Lipson, Schaums Outline Series, 2009 McGraw Hill.

Paper: DSE1B Nuclear and Particle Physics

Nuclear and Particle Physics - (Theory) :DSE1BT **Credits: 5 (+1 for Tutorial)**

Total Lecture-56

a. Recapitulation of general properties of nuclei, nuclear models and radioactivity.
b. Nuclear Reactions (a) 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).
c. Interaction of Nuclear Radiation with matter
   (a) Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron's interaction with matter.
d. Detector for Nuclear Radiations
   (a) Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semi- conductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

5. Particle Accelerators

(a) Accelerator facility available in India: Van-de Graaf generator (Tan- dem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

6. Particle Physics

(a) Fundamental particles and their families. Fundamental particle-interactions and their basic features. 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. Quark structure of hadrons.

Reference Books

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000). 67
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier,

2007).

- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991).

Paper: DSE2A :Applied Dynamics

Applied Dynamics - (Theory): DSE2AT **Credits: 4**
Total Lecture-24

1. Small Amplitude Oscillations

14. 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.

2. Dynamical Systems

(a) Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator, pendulum. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition. Other examples of dynamical systems - Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits In Chemistry: Rate equations for chemical reactions e.g. autocatalysis, bi-stability In Economics: Examples from game theory. Illustrative examples from other disciplines. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples. Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

3. Introduction to Chaos and Fractals

(a) Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer. Self-similarity and fractal geometry: Fractals in nature -trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Chaos in nonlinear finite difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos. Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

Reference Books

- Classical Mechanics: A Course of Lectures. A.K. Raychaudhuri, 1983, Oxford University Press.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.

Advanced Dynamics - (Practical): DSE2ATP **Credits: 2**

Total Lecture-32

List of Practicals

1. To draw the phase portrait of damped harmonic oscillator using numerical techniques.
2. To draw the phase portrait of a pendulum with di erent values of energy using numerical techniques.
3. To study logistic growth population model for di erent parameter values drawing cobweb diagrams (few steps).
4. To study the phenomenon of chaos in logistic growth model using simple computer programs and to estimate the corresponding Lyapunov expo- nent.
5. Computational visualization of trajectories in the Sinai Billiard.
6. Visualization of fractal nature of the chaotic attractors in logistic map by numerically generating the orbit diagram fractal.
7. Computational visualization of formations of a self-similar fractal structure such as middle third cantor set.

Reference Books

- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007.
- Chaos An Introduction to Dynamical Systems, K. T. Alligood, T. D. Sauer and J. A. Yorke, Springer.
- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
- Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scienti c and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

Paper: DSE2B: Communication Electronics

Communication Electronics - (Theory): DSE2BT **Credits: 4**

Total Lecture-24

1. Electronic communication

(a) Introduction to communication means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

2. Analog Modulation

(a) Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

3. Analog Pulse Modulation

(a) Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

4. Digital Pulse Modulation

(a) Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK).

5. Introduction to Communication and Navigation systems:

(a) Satellite Communication Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and down- link.
(b) Mobile Telephony System Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only).

Reference Books

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6th edition, Pren- tice Hall.
- Electronic Communication systems, G. Kennedy, 3rd Edn, 1999, Tata McGraw Hill.
- Principles of Electronic communication systems Frenzel, 3rd edition, McGraw Hill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

Communication Electronics - (Practical) : DSE2BP **Credits: 2**

List of Practicals

1. To design an Amplitude Modulator using Transistor

2. To study envelope detector for demodulation of AM signal

3. To study FM - Generator and Detector circuit

4. To study AM Transmitter and Receiver

5. To study FM Transmitter and Receiver

6. To study Time Division Multiplexing (TDM)

7. To study Pulse Amplitude Modulation (PAM)

Reference Books

- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Electronic Communication system, Blake, Cengage, 5th edition.

Paper: DSE3A:Advanced Mathematical Methods - II

Advanced Mathematical Methods - II - (Theory): DSE3AT **Credits: 5 (+1 for Tutorial)**

Total Lecture-56

1. Tensors
   (c) Cartesian Tensors. Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law. Electric Susceptibility tensor.
   (d) General Tensors. Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Metric Tensor.
2. Group Theory
   (a) Groups: Elementary properties of groups, uniqueness of Identity, Inverse, Rearrangement theorem. Conjugate relations, Classes, Subgroup, Invariant Subgroups, Co-sets, Co-set

multiplication, Factor Groups. Centre of a group. Cyclic group, Permutation groups and Transformation Groups. Homomorphism and Isomorphism of groups, Kernel.

(b) Matrix Representations of Groups Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses.

(c) Lie Groups: Definition using metric associated with faithful finite dimensional matrix representation. Connected component and Connected Lie group. Compact Lie group.

(d) Lie Algebra: Definition, Lie Product and Structure constants. Lie Subalgebra, Invariant Lie Subalgebra. Homomorphism and Isomorphism of Lie Algebras. Representations of Lie Algebras.

(e) Connection of Lie Groups with Lie Algebra. The matrix exponential and its properties. Fundamental theorem of Lie Algebra. Analytic curves and Tangent vectors in Lie Groups. One parameter Subgroups and the exponential map connection. Special cases of connected and compact Lie groups. Constructing representations of Lie Algebras using corresponding analytic representations of Lie Groups.

(f) SO(3), SU(2) and SU(3) groups as examples.

Reference Books

- Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
- Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
- Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
- GroupTheory and its ApplicationstoPhysicalProblemsbyMortonHamer- mesh, 1989, Dover.
- Group Theory in Physics, Volume I & II, J.F.Cornwell, Academic Press, 1984.

Paper: DSE3B :Classical Dynamics

Classical Dynamics(Theory): DSE3BT **Credits: 5 (+1 for Tutorial)**

Total Lecture-56

1. Classical Mechanics of Point Particles:

   (a) Review of Newtonian Mechanics;
   (b) 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. Generalized coordinates and velocities,
   (c) Hamilton‟s principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional
   (d) Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta

2. Hamiltonian.

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

3. Small Amplitude Oscillations:

   (a) 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
   (b) Example of N identical masses connected in a linear fashion to (N -1) - identical springs.

4. Special Theory of Relativity:

   (a) Postulates of Special Theory of Relativity. Lorentz Transformations.Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox.
   (b) Four-vectors: space-like, time-like and light- like. Four-velocity and acceleration.Metric and alternating tensors.Four-momentum and energy- momentum relation.
   (c) 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.

5. Fluid Dynamics:

   (a) Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille‟s equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

Reference Books:

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002,Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
- Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
- Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
- Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Paper: DSE4A:Astronomy and Astrophysics

Astronomy and Astrophysics - (Theory): DSE4AT **Credits: 5 (+1 for Tutorial)**

Total Lecture-24

1. Astronomical Scales Astronomical Distance.

   (a) Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical

Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

2. Astronomical techniques

(b) Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Tele- scope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes).

3. Physical principles

(c) Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

4. The sun and solar family

(d) The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto- hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification). Main sequence, red giants and white dwarfs, Chandrashekhar mass limit, possibility of Neutron star.

5. The milkyway

(e) Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

6. Galaxies

(f) Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

7. Large scale structure & expanding universe

(g) Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using

Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

Reference Books

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
- Fundamentals of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- K.S. Krishnasamy, `Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
- Baidyanath Basu, `An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi, 2001.
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication

Paper: DSE4B:Nano Materials and Applications

Nano Materials and Applications - (Theory): DSE4BT **Credits: 5 (+1 for Tutorial)**

Total Lecture-56

1. Nanoscale Systems

(h) Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- In finite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

2. Synthesis of Nanostructure Materials

(a) Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor de- position (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

3. Characterization

15. X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

4. Optical Properties

(c) Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and

charging of nanostructure. Quasiparticles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization- absorption, emission and luminescence. Optical properties of heterostructures and nanostructures.

5. Electron Transport

(a) Carrier transport in nanostrucutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

6. Applications

(a) Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial De- vices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Reference Books

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
- Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
- Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

Syllabi for Skill Enhancement Courses (Honours)

Paper: SEC1A:Electrical Circuits and Network Skills

Electrical Circuits and Network Skills - (Theory): SEC1A **Credits: 2**

Total Lecture-16

1. Basic Electricity Principles

(a) Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

2. Understanding Electrical Circuits

(a) Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

3. Electrical Drawing and Symbols

(a) Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

4. Generators and Transformers

(a) DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

5. Electric Motors

(a) Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

6. Solid-State Devices

(a) Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

7. Electrical Protection

(a) Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

8. Electrical Wiring

(a) Different types of conductors and cables. Basics of wiring - Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.

Reference Books

• A text book in Electrical Technology - B L Theraja - S Chand & Co.

• A text book of Electrical Technology - A K Theraja.

• Performance and design of AC machines - M G Say ELBS Edn

Paper: SEC1BT :Computer Algebra System & Figure Drawing Skill

Computer Algebra System & Figure Drawing Skill - (Theory): SEC1BT **Credits: 2**

Total Lecture-16

Elementary symbolic computation using some computer algebra system (CAS) like Yacas or Maxima.

(a) Arithmetic and other operations on numbers,
(b) Calculus and elementary functions, Simplification of expressions, Solvers, Differential Equations.
(c) Linear Algebra
(d) Operations on polynomials
(e) List operations
(f) Predicates
(g) Input/output and plotting
(h) Probability and Statistics
(i) Numerical methods using CAS
(j) Physics specific applications

Figure generation using drawing tools like x g/ latexdraw/ inkscape etc.

(a) Drawing lines with/without arrows with different line styles.
(b) Drawing curves with different line styles including brazier curves.
(c) Drawing different types of shapes including circle, ellipse, polygons etc.
(d) Changing figure properties like position, colour, orientation, size, shape, line properties, filling properties etc.
(e) Grouping and ungrouping of figures.
(f) Exporting the figure into different file formats.

Reference Books

- https://yacas.readthedocs.io/en/latest/reference_manual/
- The Maxima Book; Paulo Ney de Souza Richard J. Fateman Joel Moses Cli Yapp; http://maxima.sourceforge.net/docs/maximabook/maximabook- 19-Sept-2004.pdf.
- Get Started With Maxima: https://www.whoishostingthis.com/resources/maxima/

Paper: SEC2A:Renewable Energy and Energy Harvesting

Renewable Energy and Energy Harvesting - (Theory): SEC2AT **Credits: 2**

Total Lecture-16

1. Fossil fuels and Alternate Sources of energy

(i) Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Ocean shore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

2. Solar energy

(j) Solar energy, its importance, storage of solar energy, solar pond, non- convective solar pond, applications of solar pond and solar energy, solar water heater, at plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

3. Wind Energy harvesting

(k) Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

4. Ocean Energy

(l) Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

5. Geothermal Energy

(a) Geothermal Resources, Geothermal Technologies.

6. Hydro Energy

(b) Hydropower resources, hydropower technologies, environmental impact of hydropower

sources.

7. Piezoelectric Energy harvesting

(a) Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

8. Electromagnetic Energy Harvesting

(m) Linear generators, physics mathematical models, recent applications (b) Carbon captured technologies, cell, batteries, power consumption.
(n) Environmental issues and Renewable sources of energy, sustainability.

Reference Books

- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi.Solar energy - M P Agarwal - S Chand and Co. Ltd.
- Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
- Godfrey Boyle, Renewable Energy, Power for a sustainable future , 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009.
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

SEC2B: Basics of Programming and Scientific Word Processing

Basics of Programming and Scientific Word Processing - (Theory): SEC2BT **Credits: 2**

Total Lecture-16

1. Elements of Programming

(a) An overview computers: History of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language.
(b) Algorithms and Flowcharts:
    i. Algorithm - definition, properties and development.
    ii. Flowchart - Concept of flowchart, symbols, guidelines, types.

2. Basic programming in C/FORTRAN

(o) Constants, Variables and Data types.
(p) Operation and Expressions - Arithmetic operators, relational opera- tors, logical operators.
(q) Managing input/output.
(r) Decision Making and Branching.
(s) Decision making and Looping.
(t) Arrays : One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
(u) User-defined Functions.

3. Visualization

(c) 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 le, saving and exporting, multiple data sets per le, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot.

4. Scientific word processing:

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

Reference Books

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Computer Programming in Fortran 77 . V. Rajaraman (Publisher: PHI).
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipschutz and A Poe, 1986Mc-Graw Hill Book Co.
- Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)
- E. Balagurnsamy, Programming in ANSI C, Tata McGraw Hill, 2004.
- C. Xavier, C-Language and Numerical Methods, New Age International.
- V. Rajaraman, Computer Oriented Numerical Methods, Prentice Hall of India, 1980.
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010).
- LaTeX A Document Preparation System , Leslie Lamport (Second Edi- tion, Addison- Wesley, 1994).

Syllabi for Core Courses (General)

These courses will also serve as Generic Elective (GE) courses for students who have honours in a subject other than Physics.

GE-1: Mechanics

Mechanics (Theory): GE-1T **Credits: 4**

Total Lecture-24

1. Mathematical Methods

(a) Vector Algebra: Vectors as directed line segments. Addition of vectors and multiplication by a scalar. Scalar and vector products. Basis and representation of vectors. (b) Vector Analysis: Derivatives of a vector with respect to a parameter. Gradient, divergence and Curl. Vector integration, line, surface and volume integrals of vector elds. Gauss'-divergence theorem and Stoke's theorem of vectors (Statement only).

2. Laws of Motion

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

3. Work and Energy

(a) Work-energy theorem. Conservative forces. Concept of Potential Energy. Conservation of energy.

4. Gravitation

(a) Motion of a particle in a central force field. Conservation of angular momentum leading to restriction of the motion to a plane and constancy of areal velocity. Newton's Law of Gravitation. Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness.

5. Oscillations

(a) Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. Forced oscillations with harmonic forces. Compound pendulum.

6. Rotational Motion

(a) Rotation of a rigid body about a fixed axis. Angular velocity and angular momentum. Moment of Inertia. Torque. Conservation of angular momentum.

7. Elasticity

(a) 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. (b) Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion. Torsional pendulum. (c) Bending of beams. (d) Work done in stretching and work done in twisting a wire.

8. Surface Tension

(a) Synclastic and anticlastic surface - Excess of pressure - Application to spherical drops and bubbles - variation of surface tension with temperature.

9. Viscosity

(a) Rate of liquid in a capillary tube - Poiseuille's formula.

Reference Books

• University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison- Wesley

• Mechanics Berkeley Physics course,v.1: Charles Kittel, et. Al. 2007, Tata McGraw- Hill.

• Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley.

• Engineering Mechanics, Basudeb Bhattacharya, 2 nd edn., 2015, Oxford University Press.

• Physics for Degree Students (For B.Sc. 1st Year); C.L. Arora & P.S. Hemme; S.Chand Publishing.

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

Mechanics (Practical): GE-1P **Credits: 2**

Total Lecture-32

1. To determine the Moment of Inertia of a metallic cylinder/rectangular bar about an axis passing through its centre of gravity.
2. To determine the Young's Modulus of the material of a beam by the method of Flexure.
3. To determine the Modulus of Rigidity of the material of a Wire by Statical method.
4. To determine the Young's modulus of the material of a Wire by Searle's method.
5. To determine g by Bar Pendulum.
6. To determine g by Kater's Pendulum.
7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

Reference Books

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

• Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

• A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

• Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

• Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

GE-2: Electricity and Magnetism

Electricity and Magnetism (Theory) : GE-2T **Credits: 4**

Total Lecture-24

1. Electrostatics

(a) Coulombs law. Principle of superposition. Electrostatic Field. (b) Divergence of the Electrostatic field. Flux, Gauss's theorem of electrostatics. Applications of Gauss theorem to and Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. (c) Curl of the Electrostatic Field. Electric potential as line integral of electric field. Potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Electric potential and field due to an electric dipole. Electric dipole moment. Force and Torque on a dipole. (d) Conductors: Electric field and charge density inside and on the surface of a conductor. Force per unit area on the surface. Capacitance of a conductor. Capacitance an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic eld. (e) Electric Fields inside matter: Electric Polarisation. Bound charges. Displacement vector. Gauss's theorem in dielectrics. Linear Dielectric medium. Electric Succeptibility and Permittivity. Parallel plate capacitor completely lled with dielectric.

2. Magnetism

(a) Biot-Savart's law and the Lorentz force law. Application of Biot-Savart's law to determine the magnetic eld of a straight conductor, circular coil, solenoid carrying current. Force between two straight current carrying wires. (b) Divergence of the magnetic field. Magnetic vector potential. (c) Curl of the magnetic field. Ampere's circuital law. Determination of the magnetic field of a straight current carrying wire. Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole. (d) Magnetic fields inside matter: Magnetization. Bound currents. The magnetic intensity - H. Linear media. Magnetic susceptibility and Permeability. Brief introduction of dia-, para- and ferro-magnetic materials.

3. Electromagnetic Induction

4. Ohms law and denition of E.M.F. 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.

5. Linear Network

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

6. Maxwell's Equations and Electromagnetic Wave Propagation

(a) Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, Polarization of E.M. waves.

General Topic

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.

2. To study the random error in observations.

Reference Books

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

• Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.

• Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.

• Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

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

• Electricity and Magnetism; R.Murugeshan; S. Chand Publishing.

Electricity and Magnetism (Practical): GE-2P **Credits: 2**

Total Lecture-32

1. Ballistic Galvanometer:
    a. Measurement of charge and current sensitivity
    b. Measurement of Galvanometer Resistance by half deflection method

2. To compare capacitances using De'Sauty's bridge.
3. To study the I-V Characteristics of a Series RC Circuit.
4. To study a series LCR circuit LCR circuit and determineits

a. Resonant frequency

b. Quality factor

5. To study a parallel LCR circuit and determine its:

a. Anti-resonant frequency and b. Quality factor Q

6. To determine a Low Resistance by Carey Foster's Bridge.

General Topic

1. To use a Multimeter for measuring a

a. Resistances

b. AC and DC Voltages

c. DC Current

d. Checking electrical fuses.

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal

GE-3:Thermal Physics and Statistical Mechanics

Thermal Physics and Statistical Mechanics (Theory):GE-3T **Credits: 4**

Total Lecture-24

1. Laws of Thermodynamics

(a) Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamically Processes, Applications of First Law: General Relation between C_P and C_v, Work Done during Isothermal and Adiabatic Processes. Compressibility and Expansion Coefficients, Reversible and irreversible processes. Second law and Entropy, Carnot's cycle & Carnot's theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, un-attainability of absolute zero.

2.Thermo-dynamical Potentials

(a) Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications-Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_P - C_V)$, $\frac{C_P}{C_V}$, TdS equations.

3. Kinetic Theory of Gases (a) Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

4. Theory of Radiation (a) Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

5. Statistical Mechanics

(a) Phase space, Macrostate and Microstate. Ensemble - Ergodic hypothesis. Entropy and Thermodynamic probability - Boltzmann hypothesis. Maxwell-Boltzmann law - distribution of velocity - Quantum statistics (qualitative discussion only) - Fermi-Dirac distribution law (statement only) - electron gas as an example of Fermi gas - Bose-Einstein distribution law (statement only) - photon gas as an example of Bose gas- comparison of three statistics.

Reference Books

- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGrawHill.

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

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

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

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

• Heat, Thermodynamics and Statistical Physics; B. Lal, N. Subramanyam and P.S.Hemme; S.Chand Publishing.
• Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.

• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

Thermal Physics and Statistical Mechanics (Practical): GE-3P **Credits: 2**

Total Lecture-32

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
3. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
4. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
5. To determine the co efficient of linear expansion by optical lever method.

Reference Book:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

SEMESTER – 4:

GE-4:Waves and Optics

Waves and Optics (Theory):GE-4T **Credits: 4**

Total Lecture-24

1. Superposition of Two Collinear Harmonic oscillations (a) Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

2. Superposition of Two Perpendicular Harmonic Oscillation (a) Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

Wave Motion - General

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

4. Sound

(a) Review of SHM, damped & forced vibrations - resonance. Fourier's Theorem - Application to saw tooth wave and square wave. Intensity and loudness of sound - Decibels - Intensity levels. Musical notes musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

5. Wave Optics - General

(a) Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

6. Interference

(a) Interference: Division of amplitude and division of wave-front. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Bi-prism. Phase change on reaction: Stoke's treatment. Interference in Thin Films: parallel

and wedge shapedfilm. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness. Newton's Rings: measurement of wavelength and refractive index.

7. Michelson's Interferometer

(a) Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.

8. Diffraction

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

9. Polarization

10. Transverse nature of light waves. Plane polarized light - production and analysis. Circular and elliptical polarization. Optical activity.

Reference Books

• Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill.

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

• University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.

• Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications.

• Mechanics; D.S.Mathur and P.S.Hemme; S.Chand Publishing.

Waves and Optics (Practical) : GE-4P **Credits: 2**

Total Lecture-32

1. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda 2 - T$ Law.
2. Familiarization with Schuster`s focussing; determination of angle of prism.
3. To determine the Refractive Index of the Material of a Prism using Sodium Light.
4. To determine wavelength of sodium light using Newton's Rings.
5. To determine the refractive index of a liquid by the travelling microscope.
6. To determine the focal length of a concave lens by auxiliary lens method.

Reference Books:

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