Code (Prefix "CUTM")	Course Title	Credit	Type (T+P+Pj)
1483	Mathematical Physics-I	6	3-2-1
1484	Mechanics	6	3-2-1
1485	Thermal Physics	6	3-2-1
1486	Waves and Optics	6	3-2-1
1487	Mathematical Physics-II	6	3-2-1
1488	Electricity and Magnetism	6	3-2-1
1489	Analog System and Application	6	3-2-1
1490	Mathematical Physics-III	6	3-2-1
1491	Elements of Modern Physics	6	3-2-1
1492	Digital Systems and Applications	6	3-2-1
1493	Quantum Mechanics and Applications	6	3-2-1
1494	Solid State Physics	6	3-2-1
1495	Electromagnetic Theory	6	3-2-1
1496	Statistical Mechanics	6	3-2-1

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1483	Mathematical Physics-I	3-2-1	Nil

Objective

This course aims to

- To introduce the students to understand the physical meaning of different mathematical methods.
- The emphasis of course is on applications in solving problems of interest to physicists.
- Highlights the use of computational methods to solve physical problems.

Learning outcome

After successfully completing this course, the student should be able to

- Understand the mathematical and physical interpretation of vector.
- Handle different coordinate systems.
- Introduced to the concept of probability.

Course Outlline

Module-I **(6 Hours Theory+ 4 Hours Practice+ 2Hours Flipped Class)**

Matrices and Calculus:

Special types of matrices (conjugate and its transpose, periodic, Idempotent, Nilopotent, symmetric and antisymmetric, Hermitian and skew-hermitian, orthogonal and unitary matrix). Rank of a matrix, Eigen value and Eigen vector. Caley -Hamilton theorem.Approximation, Taylor and binomial series (statements only).Solution of 1st order differential equation(linear, homogeneous, non-homogeneous and exact). Wronskian and general solution. Complimentary function and Particular Integral.

Practice-1 Introduction and Overview (Computer architecture and organization, memory andInput/output devices)

Practice-2 Basics of scientific computing.

Module-II **(5 Hours Theory+ 4 Hours Practice+ 2Hours Flipped Class)**

Vector Calculus:

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

Practice-3 Errors and error Analysis

Practice-4 Algorithm

Module-III **(5 Hours Theory+ 4 Hours Practice+ 1 Hours Flipped Class)**

Vector Differentiation:

Directional derivatives and normal derivative. Gradient of ascalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Practice-5 Introduction to C language and variables, keywords, data types, operators, constants, escape sequence in C.

practice-6 Control statements (decision making and looping statements) (If‑statement. If‑else Statement. Nested if Structure. Else‑if Statement. Ternary Operator. Goto Statement. Switch Statement.

Module-IV **(6 Hours Theory+ 4 Hours Practice+ 3 Hours Flipped Class)**

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).

Practice-7 Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops.
Practice-8 Programs: Sum & average of a list of numbers, largest of a given list of numbers

Module-V **(3 Hours Theory+ 2 Hours Practice+ 2Hours Flipped Class)**

Orthogonal Curvilinear Coordinates:

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

Flipped Class-9:- Divergence, Curl and Laplacian in Cartesian and Spherical coordinates

Flipped Class-10:- Application and example of Divergence, Curl and Laplacian in cyllindrical system

Practice-9 *Solution of linear and quadratic equation.

*Using C calculate conversion of temperature from Fahrenheit to Celsius.

Module-VI (4 Hours Theory+ 4 Hours Practice+ 1Hours Flipped Class)

Introduction to probability:

Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Flipped Class-11:- Mean and variance of binomial, Gaussian and Poisson

Practice-10 Array (1 D and 2D), Strings and user defined functions.

Practice- 11 *Write a Programme to print day of the week using switch case.

*Write a programme to print first 10 natural number using for, While and do while loop.

* Write a programme to display all the even numbers within the range given by the user.

Module-VII (1 Hours Theory+ 2 Hours Practice)

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function andrectangular function. Properties of Dirac delta function.

Practice-12 *Evaluation of trigonometric functions of sine series.

*Find the real roots of a quadratic equation.

*Using C^{++} find prime number between 1 and n.

*Find the real and imaginary roots of a quadratic equation.

Total: Theory=30 Hours Practice=24 Hours & Flipped Class=12Hours

Text Books:

1. Mathematical Physics by Satyaprakash, Chand&Co.
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.

Reference Books:

1. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
2. Differential Equations, George F. Simmons, 2007, McGraw

3. Mathematical Tools for Physics, James Nearing, 2010, Dover
4. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
5. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
6. Mathematical Physics, Goswami, 1st edition, Cengage Learning
7. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
8. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley
9. Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1484	Mechanics	3-2-1	Nil

Objective

- This course would empower the student to acquire skills and practical knowledge, which help the student in their everyday life.
- This syllabus will cater the basic requirements for their higher studies.
- This course will provide a theoretical basis for doing experiments in related areas.
- This is an introductory course for undergraduate science students.

Learning outcome

- Understand the analogy between translational and rotational dynamics and application of both motions simultaneously in analyzing rolling without slipping.
- Understand the phenomena of collisions and idea about center of mass frames of reference and laboratory frames of reference and their correlation.
- Understand the non-inertial systems and the fictitious forces.
- Understand the principles of elasticity and principle of fluid flow.
- Apply Kepler's law to describe the motion of planets and satellite in circular orbit, through the study of law of gravitation.
- Explain the phenomena of simple harmonic motion and the properties of systems executing such motions.

Course outline

Module I **(4 Hours Theory+2 Hours Practice)**

Work and energy:

Work and kinetic energy theorem, conservative and non-conservative forces, potential Energy, force as gradient of potential energy, work & potential energy, work done by non-conservative forces, law of conservation of energy.

Practice-1: To verify work energy theorem using Newton's second law simulator. (Vlab)

Module II **(2 Hours Theory +4 Hours Practice+1 Hours Flipped Class)**

Collisions:

Elastic and inelastic collisions between particles, centre of mass, centre of mass and laboratory frames, two dimensional elastic collision in centre of mass frame, advantage of centre of mass frame of reference.

Practice-2: To measure the speed of a bullet and to verify the law of conservation of momentum by ballistic pendulum simulator.(Vlab)

Practice-3: Verification of elastic and inelastic collision. (Virtual lab)

Module III **(5 Hours Theory +2 Hours Practice+1 Hours Flipped Class)**

Rotational dynamics:

Angular momentum of a particle and system of particles, torque, principle of conservation of angular momentum, rotation about a fixed axis, moment of inertia, calculation of moment of inertia for rectangular, cylindrical and spherical bodies.

Practice-4: To determine the moment of inertia of a flywheel

Module IV **(3 Hours Theory)**

Non-inertial systems:

Frames of reference, inertial frames, non-inertial frames and fictitious forces, uniformly rotating frame, laws of physics in rotating coordinate systems, centrifugal force, Coriolis force and its application.

Module V **(4 Hours Theory+10 Hours Practice+1 Hours Flipped Class)**

Elasticity: Relation between elastic constants, twisting couple in a cylinder or wire.

Practice-5: To determine the Young's modulus of a wire by Searle’s method.

Practice-6: To determine the modulus of rigidity of a wire by static torsion method.

Practice-7: To determine the modulus of rigidity of a wire by torsional pendulum/Maxwell needle.

Fluid motion: Kinematics of moving fluids, Poiseuille’s equation for flow of a liquid.

Practice-8: To determine coefficient of viscosity of water by capillary flow method (Poiseuille’s method).

Practice-9: To determine coefficient of viscosity of oil by falling ball viscometer.

Module VI **(6 Hours Theory +3 Hours Flipped Class)**

Gravitation and Central force motion:

Law of gravitation, gravitational potential energy, inertial and gravitational mass, potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field, two-body problem and its reduction to one-body problem and its solution, the energy equation and energy diagram, Kepler's Laws, satellite in circular orbit and applications, geosynchronous orbits, weightlessness, basic idea of global positioning system (GPS).

Module VII **(6 Hours Theory+6 Hours Practice+6 Hours Flipped Class)**

Oscillations:

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, compound pendulums.

Practice-10: To determine the value of g using bar pendulum.

Practice-11: To determine the value of g using Kater's pendulum.

Practice-12: To determine the moment of inertia of a torsion pendulum

Total: Theory=30 Hours Practice=24 Hours & Flipped Class=12Hours

Text Book:

1. Mechanics, D.S. Mathur, S. Chand and Company Limited.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley
3. Physics for scientists and Engineers with Modern Phys. ,J.W. Jewett, R.A. Serway, 2010, Cengage Learning

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1485	Thermal Physics	3-2-1	Nil

Objective

- To acquire working knowledge of the zeroth, first and second law of thermodynamics.
- To apply the laws of thermodynamics and its application to understand thermo dynamical behavior.
- To link thermodynamics to the micro description used in Classical Statistical Mechanics.

Learning outcome

Upon successful completion of this course,

- Student identifies the relationship and correct usage of work, energy, heat capacity, specific heat, latent heat, and enthalpy.
- Student can compute entropy for simple systems such as the ideal gas (Sakur-Tetrode equation), the Einstein solid, and the two-level paramagnet.
- Student can compute the value of selected thermodynamical variables at thermal, mechanical, and/or diffusive equilibrium.
- Student can compute the efficiency of idealized engines such as the Carnot cycle, the Otto cycle, and the Diessel cycle.

Course outline

Module-I (5 Hours Theory+10 Hours Practice+2 Hours Flipped Class)
Introduction to Thermodynamics:
Zeroth and first law of thermodynamics, Extensive and intensive thermodynamic variables, Thermodynamic equilibrium, Zeroth law of thermodynamics & concept of temperature, Concept of work & heat, Conduction, Convection and Radiation, Concept of black body, State functions, First law of thermodynamics and its differential form, Applications of first law, Work and internal energy in different processes.
Practice-1: Heat transfer by conduction
Practice-2: Heat transfer by radiation

Practice-3: Heat transfer by natural convection/To determine the coefficient of thermal conductivity of a bad conductor by Lee's method

Practice-4: To determine the coefficient of thermal conductivity of Cu by Searle's

Practice-5: Black body radiation

Module-II **(4 Hours Theory+2 Hours Practice+1 Hour Flipped Class)**

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, Carnot's theorem, Refrigerator & coefficient of performance, 2nd Law of thermodynamics and applications of second law of thermodynamics, Kelvin-Planck and Clausius statements and their equivalence, Absolute scale of temperature.

Practice-6: To determine mechanical equivalent of heat, J, by Joule's calorimeter.

Module-III **(4 Hours Theory+2 Hour Practice+1 Hour Flipped Class)**

Entropy:

Concept of entropy, Phase change, 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, Temperature–entropy diagrams for Carnot's cycle, Third law of thermodynamics. Unattainability of absolute zero.

Practice-7: The study of phase change

Module-IV **(4 Hours Theory+1 Hour Flipped Class)**

Thermodynamic Potentials:

Thermodynamic potentials: internal energy, enthalpy, Helmholtz free energy, Gibb's free energy, Their definitions, properties and applications, Cooling due to adiabatic demagnetization, Clausius-Clapeyron equation, Maxwell's thermodynamic relations and applications.

Module-V **(4 Hours Theory+3 Hours Flipped Class)**

Kinetic Theory of Gases

Distribution of velocities: Maxwell-Boltzmann law of distribution of velocities in an Ideal gas, Mean, RMS and most probable speeds; degrees of freedom, Law of equipartition of energy (No proof required), Specific heats of gases.

Module-VI **(4 Hours Theory+2 Hours Flipped Class)**

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.

Module-VII **(5 Hours Theory+10 Hour Practice+2 Hours Flipped Class)**

Thermo-electricity and Newton's Law of Cooling

Introduction to Thermoelectricity, Seebeck Effect, Peltier Effect, Thermoelectric Devices, Thermistor, Newton's Law of Cooling

Practice-8: To determine the temperature coefficient of resistance by platinum resistance thermometer (PRT)

Practice-9: Thermo couple Seebeck effect
Practice-10: To study the variation of thermo-emf of a thermocouple with difference of temperature of its two junctions
Practice-11: Characteristics of thermistor
Practice-12: Newton's law of cooling

Total theory 30 hours, total practice 24 hours and total flipped class 12 hours

Textbook:

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

Reference Books:

1. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
2. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
3. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger 1988, Narosa.
5. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.
6. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1486	**Waves and Optics**	3-2-1	Nil

Objective

- To aware the students about the various phenomena of waves and optics.
- To solve many types of problems involving wave motion.
- To understand the phenomenon like Interference, Diffraction tHoursough practice mode.

Learning Outcome
Upon successful completion of this course, students will be able to:

- Understand the physics behind various phenomena in waves and optics.

- Understand various natural phenomena (like interference and diffraction) that are happening in their surroundings.
- Understand longitudinal, transverse waves and their applications.

Course outline

Module-I **(6 Hours Theory+3 Hours Flipped Class)**

Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats).

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

Module-II **(2 Hours Theory +1 Hours Flipped Class)**

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Module-III **(6 Hours Theory+2 Hours Flipped Class)**

Superposition of Two Harmonic Waves:

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

Module-IV **(6 Hours Theory+4 Hours Practice+2 Hours Flipped Class)**

Wave Optics

Interference:

Huygens Principle. Division of amplitude and wave front. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination

(Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Practice 1. To determine the wavelength of sodium light using Newton's Rings.

Practice 2. To determine the refractive index of liquid using Newton's Rings.

Module-V **(2 Hours Theory+6 Hours Practice+2 Hours Flipped Class)**

Interferometer:

Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

Practice 3. To determine the wavelength of sodium source using Michelson's interferometer.

Practice 4. To determines the refractive index of a thin glass plate using Michelson's interferometer.

Practice 5. To determine the wavelength of a laser using Michelson's interferometer.

Module-VI **(4 Hours Theory + 4 Hours Practice+1 Hours Flipped Class)**

Fraunhofer diffraction:

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

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

Practice 7. To determine dispersive power and resolving power of a plane diffraction grating.

Module-VII **(4 Hours Theory+10 Hours Practice+1 Hours Flipped Class)**

Fresnel Diffraction:

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. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Practice 8. To study Lissajous Figures.

Practice 9. To calculate the velocity of ultrasonic sound tHoursough different liquid media

Practice 10. To calculate the adiabatic compressibility of the given liquid

Practice 11. To calculate the beam of divergence and spot size of the given laser beam.

Practice 12. To investigate the motion of coupled oscillators

Total theory 30 hours, total practice 24 hours and total flipped class 12 hours

Text Books:

1. Optics, AjoyGhatak, 2008, Tata McGraw Hill

Reference Books:

1.Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
5. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
6. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. ChandPublications.

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1487	Mathematical Physics-II	3-2-1	Nil

Objective

This course aims to

- Fourier series and its application to the solution of partial differential equations.
- Study of Second order linear differential equations and their importance
- Introduce the concepts of Laplace equation, its application, basic statistical data analysis and curve fitting.

Learning outcome

After successfully completing this course, the student should be able to

- Fourier series and its application to the solution of partial differential equations.
- Study of Second order linear differential equations and their importance

- Introduce the concepts of Laplace equation, its application, basic statistical data analysis and curve fitting.

Course Outline

Module I (6 Hours Theory+ 4 Hours Practice+ 1 Hour Flipped Class)

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.

Practice-1 Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window

Practice-2 Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Subarray

Module-II (5 Hours Theory+ 4 Hours Practice+ 2 Hours Flipped Class)

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.

Practice-3 Special values, Displaying output data, data file, Scalar and array operations Hierarchy of operations, Built in Scilab functions

Practice-4 Introduction to plotting, 2D and 3D plotting

Module-III (5 Hours Theory+ 4 Hours Practice+ 2 Hours Flipped Class)

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.

Practice-5 Branching Statements and program design, Relational & logical operators

Practice-6 The while loop, for loop, details of loop operations, break & continue statements

Module-IV (4 Hours Theory+ 4 Hours Practice+ 2 Hours Flipped Class)

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 ($J_o(x)$ and $J_1(x)$)and Orthogonality.

Practice-7 Curve fitting for experimental Data. Solution of AX=B Using Gauss Elimination.

Practice-8 Numerical Integration using Trapizoidal Rule and Simpson's Rule

Module-V (3 Hours Theory+ 2 Hours Practice+ 2 Hours Flipped Class)

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

Practice-9 Find the eigen value and eigen vector of the input matrix. Solution Of Radioactive decay .

Module-VI (3 Hours Theory+ 4 Hours Practice+ 1 Hours Flipped Class)

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.

Practice-10 An introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program

Practice-11 Ohms law to calculate R, Hooke's law to calculate spring constant.

Module-VII (4 Hours Theory+ 2 Hours Practice+ 2 Hours Flipped Class)

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

Practice-12 Solution of simple pendulum and Double Pendulum using Euler and RK4 method

Total Theory 30 hours, Total Practice 24 Hours, Total Flipped Class 12 hours

Text Book:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.

Reference Books:

1. Mathematical Physics by B.S.Rajput, APragati
2. Mathematical Physics by Satyaprakash, Chand&Co.
3. Introduction to Mathematical Physics by Charlie
4. Mathematical Physics by H.K.Dass and Dr. Rama Verma, S.Chand
5. Mathematical Physics by D.Gupta.
6. Fourier analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
7. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1488	**Electricity and Magnetism**	3-2-1	Nil

Objective

- Study the electric and magnetic fields in details.
- Study and explore the dielectric properties of matter.
- Study the relation between electric and magnetic fields.

Learning outcome

Upon successful completion of this course, students will be able to:

- Understand the characteristics and properties of electric and magnetic fields.
- Understand the behavior and use of dielectrics.
- Understand the Maxwell equation and their usefulness.
- Experiences electricity & magnetism in practice mode

Course outline

Module-I (4 Hours Theory+2 Hours Flipped Class)

Electric field:

Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Module-II (4 Hours Theory + 2 Hours Practice+1 Hour Flipped Class)

Electrostatic energy:

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Practice 1: Determination dielectric constant by using parallel plate capacitors

Module-III (2 Hours Theory+1 Hour Flipped Class)

Dielectric Properties of Matter:

Electric Field in matter. Polarization, PolarizationCharges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

Module-IV (6 Hours Theory + 4 Hours Practice+6 Hours Flipped Class)

Magnetic Field:

Magnetic force between current elements and definition of MagneticFieldB. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Practice 2: To study the variation of magnetic field with distance along the axis of a circular coil carrying current.

Practice 3: To determine the reduction factor of the given tangent galvanometer (K).

Module-V (6 Hours Theory + 6 Hours Practice+1 Hour Flipped Class)

Electromagnetic Induction:

Faraday's Law. Lenz's Law. Self-Inductance and MutualInductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Practice 4: To determine self-inductance of a coil by Anderson's bridge.
Practice 5: To determine self-inductance of a coil by Rayleigh's method.
Practice 6: To determine the mutual inductance of two coils

Module-VI (4 Hours Theory + 8 Hours Practice+1 Hour Flipped Class)

Electrical Circuits:

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactanceand Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3)

Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Practice 7: To design series RC circuit and find out the current flowing thorugh each component.
Practice 8: To design series LC circuit and find out the current flowing thorugh each component.
Practice 9: To design Series RL circuit and find out the current flowing thorugh each component.
Practice 10: To study the variation in current and voltage in a series LCR circuit

Module-VII (4 Hours Theory + 4 Hours Practice)

Network theorems:

Ideal Constant-voltage and Constant-current Sources. NetworkTheorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Practice 11: To verify the Thevenin theorems.
Practice 12: To verify the Norton theorems

Total theory 30 hours, total Practice 24 hours and 12 hours Flipped Class

Text Books:

1. Electricity and Magnetism by D.C.Tayal, Himalaya Publishing House.

Reference Books:

1. Electricity and Magnetism - K. K. Tiwari
2. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
3. Engineering Electromagnetics by W.H.Hayt&J.A.Buck.
4. Introduction to Electrodynamics by D J Griffiths, PHI Learning, 2009.
5. Electricity and Magnetism - Segal, Chopra, Segal.

6. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
7. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1489	Analog System and Application	3-2-1	Nil

Objective

- The objectives of this subject are to Learn Fundamentals of electronic devices.
- Design and Applications of electronic circuits.
- Learn through practice mode the fundamental electronic devices

Learning outcome

Upon successful completion of this course, students will be able to:

- Student identifies the relationship and correct usage of work, energy, heat capacity, specific heat, latent heat, and enthalpy.
- Understand Semiconductor diodes, bipolar junction transistor.

- Sketch, explain and design the amplifier circuit for given specification and analyze them discuss oscillator principles, and frequency stability.
- Analyze the different types of Oscillators

Course outline

Module I (4 Hours Theory+2 Hours Practice+1 Hours Flipped Class)

Semiconductor Diodes:

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 Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

Practice-1: V-I characteristics of PN junction diode

Module II (4 Hours Theory+ 4 Hours Practice+2 Hours Flipped Class)

Two-terminal Devices and their Applications:

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

Practice-2: V-I characteristics of Light emitting diode.

Practice-3: V-I characteristics of a Zener diode and its use as voltage regulator.

Module III (5 Hours Theory+ 2 Hours Practice+1 Hours Flipped Class)

Bipolar Junction transistors:

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

Practice-4: To study the characteristics of a Bipolar Junction Transistor in CE, CB and CC configuration

Module IV (5 Hours Theory+ 2 Hours Practice+1 Hours Flipped Class)

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.

Practice-5: To study the various biasing configurations of BJT for normal class A ,B and C operation.

Module V (4 Hours Theory+ 1 Hours Practice+1 Hours Flipped Class)

Coupled Amplifier:

Two stage RC-coupled amplifier and its frequency response

Feedback in Amplifiers:

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

Practice-6: To study the frequency response of voltage gain of a RC-coupled transistor amplifier

Module VI (3 Hours Theory+ 4 Hours Practice+2 Hours Flipped Class)

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.
Practice-7:inverting amplifier using Op-amp (741,351) for dc voltage of given gain
Practice-8:inverting amplifier using Op-amp (741,351) and study its frequency response
Practice-9:non-inverting amplifier using Op-amp (741,351) & study its frequency response.
Module VII (5 Hours Theory+6 Hours Practice +2 Hours Flipped Class)
Applications of Op-Amps:
(1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.
Practice-10: To study the zero-crossing detector and comparator.
Practice-11: Two dc voltages using Op-amp in inverting and non-inverting mode.
Practice-12: To investigate the use of an op-amp as a Differentiator and Integrator.
Total theory 30 hours , total Practice 24 hours and total Flipped Class 12 hours
Textbook:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill

Reference Books:

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

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1490	Mathematical Physics-III	3-2-1	Nil

Objective

This course aims to

- The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical physics.
- The laws of physics are often expressed tHoursough the relatively complex mathematical apparatus.
- This course is intended to give mathematical tools necessary for a better understanding of the later courses in physics such as classical electrodynamics, quantum mechanics, solid-state physics, and statistical physics.

Learning outcome

After successfully completing this course, the student should be able to

- Perform algebra of complex numbers
- Express analytic complex function as power series.
- Identify the isolated singularities of a function and determine the types of singularity
- Calculate the Laplace Transform of basic functions using the definition
- Able to solve complex integrals
- Use the residue theorem to compute some definite integrals

Course Outline

Module I (4 Hours Theory+ 6 Hours Practice+ 2 Hours Flipped Class)

Complex Analysis Basic Concepts

Motivation and introduction to Complex analysis; Brief revision of complex no and their graphical representation; the triangular inequality. Polar coordinates; Euler's formula and complex exponentials, polar form; Roots of the complex number- nth root, De-Moivers theorem; Representing complex multiplication as matrix multiplication, examples; Numerical problems

Practice-1: Basics of python

Practice-2: Basics of Python

Practice- 3: Basics of Python

Module II (6 Hours Theory+ 6 Hours Practice+ 1 Hours Flipped Class)

Analytic function Basic Concepts-II

The derivative preliminaries. Numerical problems; Limits and continuous functions. Properties of limits and continuous functions, limit involving infinity; Branch cut, branch point and branches. Numerical problems; Cauchy-Riemann equation. Numerical problems; Complex line integral. Cauchy Integral theorem; Singular points, poles; Cauchy Integral formula for functions; Cauchy Integral formula for derivatives. Numerical problems; Harmonic function; Complex line integral.Cauchy Integral theorem; Numerical problems; Singular points, poles; Cauchy Integral formula for functions; Cauchy Integral formula for derivatives. Numerical problems: Harmonic function

Practice-4: Compute nth roots of unity for n=2, 3, 4....

Practice-5: Find the Fourier Transform of exp(-x2)

Practice -5: Integrate 1/(x2+1) numerically and check with computer

Module III (4 Hours Theory+ 1 Hour Flipped Class)

Taylor and Laurent series:

Finite and infinite geometric series, convergence of power series; Taylor series; Numerical problems: Singularities, types of singularities; Laurent's series, examples;

Module IV (3Hours Theory+ 2 Hour Flipped Class)

Residues:

Poles and residues;Residue theorem; Examples of poles and residues; Examples of poles and residues; Application of Residue theorems; Numerical problems-Solution of some definite integral using Residue theorem

Module V (6 Hours Theory+ 4 Hours Practice+ 1 Hour Flipped Class)

Fourier Transform:

Introduction, Fourier Integral trans form, examples; Fourier transforms- sine and cosine transforms; Fourier transform properties; Inverse Fourier transform, examples; Fourier transform- infinite wave train, Dirac Delta function and Gaussian function; Convolution of Fourier transform, Parseval Identity. Numerical Problems; Application of Fourier transform to one dimensional wave equation

Practice-7: Compute the Fourier Transform of exp(-x2)using Python and compare with numerically calculated solution

Module VI (2 Hours Theory+6 hours practice+1 Hour Flipped Class)

Laplace Transform;

Introduction. Laplace transform of elementary function; Properties of Laplace transform;; Examples LT of 1st and 2nd order derivative; Inverse Laplace Transform; Examples LT of 1st and 2nd order derivative; Numerical problems; LT of a unit step function, Dirac Delta function; Application of LT to 2nd order differential equation, Application to damped harmonic oscillator. Impulse function and Lcr circuits

Practice-8: Solve Kirchoff's current law for any node of an arbitrary circuit using LT

Practice-9: Solve Kirchoff's voltage law for any node of an arbitrary circuit using LT

Practice-10: Perform circuit analysis of a general LCR circuit using Laplace Transform

Module VII **(5 Hours Theory + 4 hours practice)**

Green's Function:

Introduction. Greens function for the one-dimensional problem; Construction of Greens function; Non-homogeneous boundary value problem; Homogeneous Boundary condition. Sturm-Liouville problem; Eigenvalue and Eigen function expansion of Greens function; Parseval Formula- complete condition for the Eigen function

Practice 11: Derive the Green's function for the operator d2/dx2 with boundary condition y(0)=0 and y(1)=0

Practice 12: Find an appropriate Green's function for the equation y"+1/4y=f(x) with boundary condition y(0)=y(π)=0

Total Theory 30 hours, Total Practice 24 Hours, Total Flipped Class 10 hours

Textbook:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier

Reference Books:

1. Mathematical Physics by B.S.Rajput, Pragati Edition.
2. Mathematical Physics by Satyaprakash, S.Chand&Co.
3. Introduction to Mathematical Physics by Charlie Harper.
4. Mathematical Physics by H.K.Dass and Dr. Rama Verma, S.Chand Publication.
5. Mathematical Physics by B.D.Gupta.

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1491	Elements of Modern Physics	3-2-1	Nil

Objective

- This course covers certain conceptual courses of physics by virtue of which the students will be able to understand some concepts of Quantum Mechanics, Atomic Physics and Nuclear Physics.
- It also imparts the basic principles of Quantum mechanics, Schrodinger equation and its applications
- To introduce students to the fundamentals of atomic physics and nuclear physics.
- To introduce them to the basic Laser principles and Properties.

Learning outcome

Upon successful completion of this course, students will be able to:

- Understand and explain the differences between classical and quantum mechanics.
- Solve Schrodinger equation for simple potentials.
- Assess whether a solution to a given problem is physically reasonable.
- Identify properties of the nucleus and other sub-atomic particles.
- Describe theories explaining the structure of atoms and the origin of the observed spectra.
- Explain different Laser used and make a comparison between them.

Course outline

Module-I **(7 Hours Theory+8 Hours Practice+3 Hours Flipped Class)**
Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

Practice-1: Measurement of Planck's constant using black body radiation and photo-detector
Practice-2: Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
Practice-3: To determine the wavelength of H-alpha emission line of Hydrogen atom.
Practice-4: To determine the ionization potential of mercury.

Module-II **(3 Hours Theory+4 Hours Practice+1 Hour Flipped Class)**
Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating

minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.

Practice-5: To setup the Millikan oil drop apparatus and determine the charge of an electron.

Practice-6: To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

Module-III **(4 Hours Theory)**

Entropy:

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

Module-IV **(2 Hours Theory+2 Hours Practice)**

One dimensional infinitely rigid box- energy eigenvalues and Eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier.

Module-V **(5 Hours Theory)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

Module-VI **(6 Hours Theory)**

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.Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons.

Module-VII **(5 Hours Theory+8 Hour Practice+6 Hours Flipped Class)**

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.

Practice-8: To determine the wavelength of laser source using diffraction of double slits.

Practice-9: To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Practice-10: To show the tunneling effect in tunnel diode using I-V characteristics.

Practice-11: Monte-Carlo Simulation of charged particle induced effects on various materials

Practice-12: (Sputtering Calculation) Monte-Carlo Simulation of charged particle induced effects on various materials

Flipped Classs: Monte-Carlo Simulation of charged particle induced effects on various materials (SRIM & IRADINA)

Total theory 30 hours, total practice 24 hours and total flipped class 12 hours

Textbook:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

Reference Books:

1. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
2. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
3. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
4. Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan
5. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
6. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2ndEdn, Tata McGraw-Hill Publishing Co. Ltd.
7. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

Text Books (Practice)
1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
Reference Books:
1. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11thEdn, 2011,Kitab Mahal

Reference Books (Flipped Classs on Monte-Carlo Simulation) : SRIM, The stopping and range of ions in matter, James F. Ziegler, Jochen P. Biersack, Matthias D. Ziegler

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1492	**Digital Systems and Applications**	3-2-1	Nil

Objective

- To make the student understand the digital system.
- To understand the Boolean algebra and data processing circuit.
- Knowing computer architecture.
- Understanding the arithmetic and sequential circuit and microprocessors.

Learning Outcome
Upon successful completion of this course, students will be able to:

- Gain both theoretical and experimental knowledge about digital electronics.
- Understand computer architecture.
- Verify and design various logic gates.
- Write programs using 8085 microprocessor.

Course outline

Module-I **(3 Hours Theory)**

Introduction to CRO:
Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Module-II **(3 Hours Theory +2 Hours Flipped Class)**

Integrated Circuits (Qualitative treatment only):

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.

Module-III **(5 Hours Theory + 10 Hours Practice + 3 Hours Flipped Class)**

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.

Practice 1. Basics of OR gate and its application in industrial control.

Practice 2. Basic NOT gate and its application in fuel level indicator.

Practice 3. Washing machine control using basic AND & NOT gates.

Practice 4. Water level control using basic AND & NOT gates.

Practice 5. Basics of AND gate and its application in car wiper control.

Module-IV **(6 Hours Theory + 4 Hours Practice+ 3 Hours Flipped Class)**

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.

Data processing circuits:

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Practice 6. Analysis and Synthesis of Boolean Expressions using Basic Logic Gates.

Practice 7. 1 Bit Full Adder using Multiplexer.

Module-V (5 Hours Theory + 10 Hours Practice+ 2 Hours Flipped Class)

Arithmetic Circuits:

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

Sequential Circuits:

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Practice 8. Analysis and Synthesis of Arithmetic Expressions using Adders / Subtractors.

Practice 9. Analysis and Synthesis of Sequential Circuits using Basic Flip-Flops.

Practice 10. To implement Half adder by using basic and universal gates.

Practice 11. To implement J-K flip-flop by using basic and universal gates.

Practice 12. To implement Parallel Binary Adder by using basic and universal gates.

Module-VI (4 Hours Theory+ 1 Hours Flipped Class)

Computer Organization:

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

Module-VII (4 Hours Theory+ 1 Hours Flipped Class)

Intel 8085 Microprocessor Architecture:

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU.

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.

Total theory 30 hours, total practice 24 hours and total flipped class 12 hours

Text Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw.

Reference Books:

1. Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, 2009, PHI Learning Pvt. Ltd.

2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
3. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning.
4. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
5. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
6. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Code	**Course Title**	**T-P-Pj (Credit)**	**Prerequisite**
CUTM1493	Quantum Mechanics and Applications	3-2-1	Nil

Objective

This course aims to

- Train the B.Sc. (Physics Honours) students with an understanding of the basic concepts of Quantum Mechanics and its mathematical frame work to describe the systems of microscopic objects (like atoms, molecules) and their properties
- Illustrate, in detail, the procedure of solving the 1D and 3D Schrodinger equations for microscopic systems interacting with time independent Central Potentials.

- Offer hands-on simulation experience of obtaining numerical solutions of Schrodinger Equation for various use-cases along with visualization of the solutions tHoursough Python
- Illustrate some present day and some futuristic applications of Quantum Mechanics like Tunnel Diodes, Scanning Tunnelling Microscopy, Bose-Einstein Condensation, Quantum Computers etc.

Learning outcome

After successfully completing this course, the student should be able to

- Solve, both analytically and numerically, time-independent and simple time-dependent Schrodinger Equations for systems of particles interacting via time-independent Central Potentials along with appropriate Boundary and Initial Conditions
- Generate appropriate visualizations of the solutions of Schrodinger Equations and interpret them
- Get a qualitative knowledge of how Quantum Mechanics operates in macroscopic devices like Tunnel Diodes, Scanning Tunneling Microscopes or large scale objects like the Sun as well as the evolving technologies like Quantum Computers and Bose-Einstein Condensates.

Course Outline

Module I (4 Hours Theory+ 4 Hours Practice+ 4 Hours Flipped Class)

Basic Concepts-I

Introduction to Quantum Mechanics (the What and Why of QMech), The relevance of Quantum Mechanics in our day-to-day life, Postulates of Quantum Mechanics; The Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in tHoursee dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Practice-1: Given candidate wave functions, check for validity of each candidate using computer visualization and compute the Position Probability Density in each valid case

Practice-2: Given candidate wave functions, check for valid wave functions using computer visualization and compute current probability density

Module II (3 Hours Theory+ 2 Hours Practice+ 2 Hours Flipped Class)

Basic Concepts-II

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

Practice-3: Free Particle wave function, Gaussian wave packet and its time evolution

Module III (7 Hours Theory+ 10 Hours Practice+ 2 Hours Flipped Class)

1D Applications:

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-1.Infinite square well potential; 2. The case of Finite Square-Well Potential and Quantum Tunneling, The working principle of Tunnel Diodes, Scanning Tunnelling Microscope, Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy and uncertainty principle for 1D Simple Harmonic Oscillator.

Practice-4 : Solution of 1D time independent Schrodinger Equation: Infinite Square Well Potential, Emergence of quantized eigenfunctions, normalization of wave function

Practice-5 : Solution of 1D Schrodinger Equation with Finite Square-Well Potential: Eigenvalues and Eigenfunctions

Practice-6 : Solution of 1D Schrodinger Equation with Finite Square-Well Potential: Tunnelling probability of wave function

Practice-7: Solution of 1D Schrodinger Equation with Harmonic Oscillator potential

Practice-8 : Solution of 1D Schrodinger Equation with Harmonic Oscillator potential, computation of eigenvalues and eigenfunctions

Module IV **(4 Hours Theory+ 4 Hours Practice+ 2 Hours Flipped Class)**

3D Applications-I (The H-Atom and Hydrogen-like cases)

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

Practice-9: Solution of radial Schrodinger equation with Coulomb Potential (Hydrogen atom)

Practice-10: Solution of radial Schrodinger equation with Coulomb Potential (Hydrogen atom), Computation of eigenvalues and eigenfunctions in Ground State

Module V **(6 Hours Theory+ 4 Hours Practice+ 1 Hour Flipped Class)**

3D Applications-II (A Single Electron Atom in External EM Fields)

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

Practice-11: Numerical solution of radial Schrodinger equation for Screened Coulomb Potential (He- and other atoms)

Module VI **(2 Hours Theory+ 1 Hour Flipped Class)**

3D Applications-III (Many Electron Atoms: Alkali Atoms)

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

Practice-12 : Numerical solution of radial Schrodinger equation with Morse Potential for

H2 molecule

Module VII **(4 Hours Theory)**

Technology Applications:

Tunnel Diode; Scanning Tunnel Microscope; Magnetic Resonance Imaging (MRI); Quantum Computations with Qubits; Bose-Einstein Condensates: A case of "Macro-atoms"

Total Theory 30 hours, Total Practice 24 Hours, Total Flipped Class 12 hours

Textbook:

Quantum Mechanics: Concepts and Applications by N Zettili, John Wiley & Sons Ltd., 2016.

Reference Books:

A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2^{nd} Ed., McGraw Hill, 2010.

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM 1494	**Solid State Physics**	(3-2-1)	Nil

Course Objective:

- Basic understanding of symmetry, electronic and thermodynamic properties of solid state systems and their technological applications.
- To impart knowledge of basic theories of the electronic structure of materials.

- Students should learn how to understand physical behavior of solids and electronic devices.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Understand the elastic properties of solids and lattice vibration.
- Have an understanding of the magnetic properties of condensed matter.
- Have an understanding of the optical properties of solids and the relation to their electronic properties.
- Develop the facility for problems associated with the solid state with respect to semi-conductor physics.
- Outline the importance of solid state physics in the modern society.

Course Outline

Module I: (3 Hours Theory+4 Hours Practice+1 Hour Flipped Class)

Crystal Structure:

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.

Practice 1: Various crystal structure

Practice 2: Interatomic vander waals forces

Module-II : (4 Hours Theory+4 Hours Practice+1 Hour Flipped Class)

Elementary Lattice Dynamics:

Lattice vibrations and phonons: Linear monoatomic lattice , Diatomiclattice Chains. Acoustical and optical Phonons. Qualitative description of the phonon spectrum in solids., Dulong and Petit's Law, Einstein theory of specific heat of solids.

Practice -3: Determination of specific heat of a solid

Practice -4: Interatomic electrostatic forces

Module III: (5 Hours Theory+8 Hours Practice+1 Hour Flipped Class)

Magnetic Properties of Matter:

Dia-, para-, ferri- and ferromagnetic materials. Classical Langevin theory of diamagnetic domains., Classical theory of paramagnetism., Quantum mechanical treatment of paramagnetism. Curie's law, Weiss's theory of ferromagnetism and ferromagnetic domains., Discussion of B-H curve. Hysteresis and energy Loss.

Practice 5: To draw the B-H curve of Fe using solenoid & determine energy loss from hysteresis.

Practice 6: Magnetic material characterization via hystersis (Remote trigger).

Practice 7: Curie temperature of paramagnetism

Practice 8: Determination of paramagnetic substance by Quinck's method.

Module-IV: (5 Hours Theory+4 Hours Practice+1 Hour Flipped Class)

Dielectric Properties of Materials:

Dielectric properties of materials: 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 equation., Complex dielectric constant. Optical phenomena.

Practice 9: Curie Weiss law of ferroelectric material.

Practice 10: Determination of dielectric constant of a material.

Module-V: (4 Hours Theory+1 Hour Flipped Class).

Superconductivity:

Experimental results. Critical temperature. Critical magnetic field., Meissner effect., Type I and type II superconductors, London's equation and penetration depth. Isotope effect, Idea of BCS theory (No derivation).

Module VI : (6 Hours Theory+4 Hours Practice+2 Hour Flipped Class).

Elementary Band Theory:

Elementary band theory, Kronig Penny model, Band gap. Classification of materials: conductor, semiconductor and insulator, Semiconductors: intrinsic and extrinsic semiconductor, Conductivity of semiconductor, mobility, Hall effect , Direct and indirect band gap semiconductors and their behavior to external field.

Practice 11: To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 0C) and to determine its band gap.

Practice 12: Hall effect

Module-VII: **(3 Hours Theory+5 Hour Flipped Class).**

Semiconductor devices.

Semiconductor materials for solar cell, Semiconductor properties, Transport properties, optical properties, Basic equations of device physics, Semiconductor materials for optoelectronic devices., Photodiode.

Total theory 30 hours, total practice 24 hours and total flipped class 12 hours.

Text Books:

1. Solid State Physics, M.A. Wahab, 2011, Narosa Publications
2. Solid State Physics, S .O.Pilai
3. Solid State Physics, Gupta Kumar

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1495	**Electromagnetic Theory**	3-2-1	Nil

Objective

- To provide the basic skills required to understand, develop, and design various engineering applications involving electromagnetic fields.
- To lay the foundations of electromagnetism and its practice in modern communications such as wireless, guided wave principles such as fiber optics and electronic electromagnetic structures.
- To understand the transverse nature of light.

Learning Outcome

Upon successful completion of this course, students will be able to:

- Apply vector calculus to static electric-magnetic fields in different engineering situations.
- Analyze Maxwell's equation in different forms.
- Examine the phenomena of wave propagation in different media and its interfaces and in applications of microwave engineering.

Course Outline

Module I

Maxwell Equations: (7Hours Theory+ 2Hours Practice+2Hours Flipped Class)

Review of Maxwell's equations. Displacement Current. 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.

Practice-1:-To study of reflection and refraction of microwave.

Module-II (3HoursTheory+ 2Hours Practice+ 1Hours Flipped Class)

EM Wave Propagation in Unbounded Media:

Plane EM waves tough vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Wave propagation tough dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation tough ionosphere.

Practice-2:- To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

Module III (4Hours Theory + 4Hours Practice +2Hours Flipped Class)

EM Wave in Bounded Media:

Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of

Reflection & Refraction. Fresnel's Formulae for perpendicular polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection.

Practice-3:- To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection.

Practice-4:- To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

Module-IV (1Hours Theory + 2Hours Practice+ 1Hours Flipped Class)

Electromagnetic Waves in anisotropic media Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula.

Practice-5:- To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction tough ultrasonic grating

Module V (7Hours Theory+ 4Hours Practice + 3Hours Flipped Class)

Polarization of Electromagnetic Waves:

Description of Linear, Circular and Elliptical Polarization.Double Refraction. Nicol Prism. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter -Wave Plates.

Practice-6:- To verify the law of Malus for plane polarized light.

Practice-7:- To measure the sample birefringence by using a Babinet's compensator.

Module-VI (5Hours Theory+ 4Hours Practice + 2Hours Flipped Class)

Rotatory Polarization:

Optical Rotation.. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

Practice-8:- To study Polarization and double slit interference in microwaves.

Practice-9:- To determine the specific rotation of sugar solution using Polarimeter.

Module-VII (3Hours Theory + 6Hours Practice+ 1Hours Flipped Class)

Optical Fibres:

Numerical Aperture. Step and Graded Indices (Definitions Only).

Single and Multiple Mode Fibres (Concept and Definition Only).

Practice-10:- To verify the Stefan`s law of radiation and to determine Stefan's constant. (2Hours)

Practice-11:- To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Practice-12:- To study dependence of radiation on angle for a simple Dipole antenna.

Total Theory=30Hours ,Total Practice=24Hours,Total Flipped Class=12Hours

Text Books:
Introduction to Electrodynamics D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

Reference Books:
1. Electrodynamics by Satya Prakash
2. A Textbook of Optics , Brijla and Subramanyam
3. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
4. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
5. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
6. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
7. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
8. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Code	**Course Title**	**T-P-Pj (Credit)**	**Prerequisite**
CUTM1496	Statistical Mechanics	3-2-1	Nil

Objective

- To relate the microscopic properties of individual atoms and molecules to the macroscopic or bulk properties of materials.
- To explore the different types of distribution functions in order to explain the behavior of the particles
- To study of quantum theory of radiation and explain black body radiations with help of the various theories and models,
- To explain the thermodynamic behavior of the atoms and molecules

Learning outcome

Upon successful completion of this course, students will be able to:

- Understand the basic properties of thermodynamics and statistical mechanics.
- Understand the blackbody radiation and distribution functions.
- Distinguish between classical and quantum radiation

Course outline

Module I **(5 Hours Theory+4 Hours Practice+1 Hours Flipped Class)**

Classical Statistics-1:

Macrostate & microstate, Elementary concept of ensemble, Phase space, Entropy and thermodynamic probability, Maxwell-Boltzmann distribution law, Partition function, Thermodynamic functions of an ideal gas.

Practice-1

Plot Maxwell-Boltzmann distribution functions with energy at different temperatures. (Using Scilab / Python)

Practice-2

Computation of the partition function Z(β) 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 statistics : Study of how Z(β), average energy <E>, energy fluctuation ΔE and specific heat at constant volume Cv depend upon the temperature and total number of particles N

Module II **(5 Hours Theory+6 Hours Practice+1 Hours Flipped Class)**

Classical Statistics-2:

Classical entropy expression, Gibbs paradox, Sackur Tetrode equation, Law of equipartition of energy (with proof) – applications to specific heat and its limitations.

Practice-3

Plot specific heat of solids according to Dulong-Petit law for high temperature and low temperature and compare them for these two cases.

Practice-4

Plot specific heat of solids according to Einstein distribution function for high temperature and low temperature and compare

Practice-5

Plot specific heat of solids according to Debye distribution function for high temperature and low temperature and compare them for these two cases.

Module III **(4 Hours Theory+2 Hours Flipped Class)**

Classical Theory of Radiation-1:

Properties of thermal radiation, Black body radiation, Pure temperature dependence, Kirchhoff's law, Stefan-Boltzmann law: thermodynamic proof.

Module IV **(4 Hours Theory+4 Hours Practice+2 Hours Flipped Class)**

Classical Theory of Radiation-2:

Radiation pressure, Wien's displacement law, Wien's distribution law, Saha's ionisation formula, Rayleigh-Jean's law, Ultraviolet catastrophe.

Practice-6

Plot Wien's distribution Law

Practice-7

Plot Rayleigh-Jeans Law

Module V **(4 Hours Theory+2 Hours Practice+2 Hours Flipped Class)**

Quantum Theory of Radiation:

Spectral distribution of black body radiation, Planck's quantum postulates, Planck's law of black body 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.

Practice-8

Plot Planck's law for black body radiation and compare it with Raleigh-Jeans law at high temperature and low temperature

Module VI **(4 Hours Theory+4 Hours Practice+2 Hours Flipped Class)**

Bose-Einstein Statistics:

B-E distribution law, Thermodynamic functions of a strongly degenerate Bose gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and thermodynamic functions of photon gas.

Practice-9

Plot Bose-Einstein distribution functions with energy at different temperatures

Practice-10

Computation of the partition function Z(β) 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 Bose-Einstein statistics : Study of how Z(β), average energy <E>, energy fluctuation ΔE and specific heat at constant volume Cv depend upon the temperature and total number of particles N

Module VII **(4 Hours Theory+4 Hours Practice+2 Hours Flipped Class)**

Fermi-Dirac Statistics:

Fermi-Dirac distribution law, Thermodynamic functions of a completely and strongly degenerate fermi gas, Fermi energy, Electron gas in a metal.

Practice-11

Plot Fermi-Dirac distribution functions with energy at different temperatures

Practice-12

Computation of the partition function Z(β) 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 Fermi-Dirac statistics : Study of how Z(β), average energy <E>, energy fluctuation ΔE and specific heat at constant volume Cv depend upon the temperature and total number of particles N

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Total theory-30 hours, total practice-24 hours and total flipped class-12 hours

Text Book:

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

Reference Books:

1. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
2. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
5. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press