Faculty of Sciences

Course Structure and Syllabi

B. Sc. (Physics Major)

2024

(New Education Policy 2020)

As Per Latest Module of UGC

Department of Physics

Indira Gandhi National Tribal University

Amarkantak 484887

Structure of the Syllabi of B.Sc. and M.Sc. (Physics) Courses

Program	Semester	Major (Core)	Minor 1	Minor 2	Multi-disciplinary	AEC	SEC	Value-added	Internship	Research Project/ Diss.	Total Credit
3-Y B.Sc./ B.A.	1st	4	2	2	3	2	3	2+2	-	-	20
	2nd	4	2	2	3	2	3	2+2	-	-	20
	3rd	8	2	2	3	2	3	-	-	-	20
	4th	14	2	2	-	2	-	-	-	-	20
	5th	14	2	2	-	-	-	-	2	-	20
	6th	16	2	2	-	-	-	-	-	-	20
4-Y B.Sc./ B.A. Hons	7th	16	2	2	-	-	-	-	-	-	20
	8th	12* + 4**	2	2	-	-	-	-	-	-	20
		Or									
4-Y B.Sc./ B.A. Hons Res	7th	16	2	2	-	-	-	-	-	-	20
	8th	4**	2	2	-	-	-	-	-	12	20
	Total Credits	60/80	24/32		9	8	9	8	2	4/12	160

*Three theory courses in lieu of 12 credits given for Research Project in 4-Y Bachelor Hons with Res.** Common for the students of Bachelor Hons

Department of Physics

Course Structure of B.Sc. (2024-2028)

	Four Years B.Sc. Programme	
COURSE_CODE	**COURSE_NAME**	**Credit(s)**
	Semester-I	
PHY-MT-103	**Mechanics (Major-I)**	**3**
PHY-MP-103	**Mechanics Lab-I**	**1**
PHY-SECT-104	**Computational Physics-1 (SEC 1-Lecture)**	**2**
PHY-SECP-104	**Computational Physics Lab-1 (SEC 1- Lab)**	**1**
PHY-MI-102	**Minor-I: Introduction to Mechanics**	**4**
PMS-MDC-100	**Logic and Computability (**Computable Mathematical Physics**)**	**3**
	Total Credits	**10 of Total 20**
	Semester-II	
PHY-MT-203	**Waves and Oscillations (Major)**	3
PHY-MP-203	**Mechanics Lab-II (Major)**	1
PHY-SECT-204	**Computational Physics-2 (SEC 2-Lecture)**	2
PHY-SECP-204	**Computational Physics-2 (SEC 2- Lab)**	1
PHY-MI-202	**Minor-II: Fundamentals of Electricity and Magnetism**	**4**
PMS-MDC-200	**Data Analytics and Statistics (**Computable Mathematical Physics**)**	3
	Total Credits	**10 of Total 20**
	Semester-III	
PHY-MT-301	**Electricity and Magnetism (Major-I)**	3
PHY-MT-303	**Mathematical Methods in Physics-I (Differential Equations) (Major-II)**	4
PHY-MP-301	**Electricity and Magnetism Lab**	1
PHY-SECT-304	**Energy Studies: Solar & Alternative Energy Sources**	3
PHY-MI-302	**Minor-III: Introduction to Thermodynamics**	**4**
PMS-MDC-300	**Computable Graph Theory (**Computable Mathematical Physics**)**	3
	Total Credits	**10 of Total 20**
	Semester-IV	
PHY-MT-401	**Thermodynamics**	4
PHY-MT-403	**Solid State Electronics**	4
PHY-MT-404	**Optics and Photonics**	4
PHY-MP-401	**Thermal Physics Lab**	1
PHY-MP-404	**Opto-Electronics Lab**	1
PHY-MI-402	**Minor-IV: Basic Wave Mechanics and Optics**	**4**
	Total Credits	**14 of Total 20**

	Semester-V	
PHY-MT-501	Mathematical Methods in Physics-II (Special Functions and Integral Transform)	4
PHY-MT-503	Modern Physics and Special Theory of Relativity	4
PHY-MT-504	Solid State Physics	4
PHY-MP-503	Virtual Lab on Special Relativity and Quantum Mechanics	2
PHY-MI-502	Minor-V: Physics of Solids	4
PHY-MT-505	Field Visit/Internship	2
	Total Credits	16 of Total 20

	Semester-VI	
PHY-MT-601	Mathematical Methods in Physics-III: Partial Differential Equations	4
PHY-MT-604	Atomic and Molecular Spectroscopy	4
PHY-MT-603	Digital and Analog Circuits & Electronic Instrumentation	4
PHY-MP-605	Analogue Electronics Lab	2
PHY-MP-603	Digital Electronics Lab	2
PHY-MI-602	Minor VI: Atomic and Molecular Physics	4
	Total Credits	16 of Total 20

	Semester-VII	
PHY-MT-701	Advanced Classical Mechanics	4
PHY-MT-704	Classical Electrodynamics-I	4
PHY-MT-703	Quantum Mechanics-I	4
PHY-MT-705	Mathematical Methods in Physics-IV: Special Mathematical Techniques	4
PHY-MP-706	Advanced Physics Lab-1	1
PHY-MP-707	Advanced Physics Lab-2	1
PHY-MI-702	Minor VII: Introductory Numerical Techniques in Physics	4
	Total Credits	16 of Total 20

	Semester-VIII	
PHY-MT-801	Statistical Thermodynamics (Compulsory)	4
PHY-MT-804	Mathematical Methods in Physics-V: Special Mathematical Methods (Elective/Optional)	4
PHY-MT-803	Advanced Numerical Techniques in Physics (Elective/Optional)	4
PHY-MT-805	Instrumentation Techniques (Elective/Optional)	4
PHY-MP-807	Lab: Great Experiments in Physics	2
PHY-MI-802	Minor VIII: Nuclear and Particle Physics Overview	4
PHY-MT-806	Dissertation (Optional) (Project Work+Dissertation+*Viva-Voce*)	12
	Total Credits	16 of Total 20

B.Sc. Honours Degree: Student who opts to study four theory courses and one lab will be entitled for B.Sc. Honours Degree.

B.Sc. Honours with Research Degree: Student who opts to study only one Compulsory Course (PHY-MT-801: Statistical Thermodynamics) and undertakes Project with Dissertation (PHY-MT-806) will be entitled for B.Sc. Honours Degree with Research. Graduate with B.Sc. Honours with Research Degree will be eligible to pursue Ph.D. directly provided he/she has requisite grades.

Remarks

1. Apart from the prescribed contents, faculty members teaching any particular course will have the discretion of eliminating 10% of the contents or including extra contents towards the same with focus on their relevance in the contemporary scientific development.

2. In lieu of a proposed 'Minor Course' a student can opt out to qualify a 'MOOCs' course of equivalent credits (2 or 4- credits) offered by UGC, provided, the student takes prior permission from the parent department in the first month of the Semester.

Programme Educational Objectives

PEO-I

Graduates would have demonstrated proficiency in problem solving and analysis.

PEO-II

Graduates will have demonstrated expertise with core Physics concepts and their application.

PEO-III

Graduates will have demonstrated ability of scientific conduct and working effectively in a laboratory environment and to pursue independent research.

PEO-IV

Students will acquire an educational foundation that prepares them for excellence, leadership roles along diverse career paths with encouragement to professional ethics and active participation needed for a successful career.

Program Outcome (PO's)

A Graduate of B.Sc. (Physics) Program will be able to demonstrate:

PO1. Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2. Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

PO3. Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO4. Effective Citizenship: Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

PO5. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO6. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

PO7. Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context sociotechnological changes.

Program Specific Outcome:

PSO1. Understand the nature and basic concepts of optics, thermodynamics, waves and oscillations and mathematical physics.

PSO2. Analyse the relationships of laws of physics with real world.

PSO3. Understand the applications of physical sciences in science and technology.

Semester-I

PHY-MT-103: Mechanics Credit(s): 3

Unit-I

Work and Energy Theorem: Work and Kinetic Energy Theorem. Conservative and Non-Conservative Forces. Potential Energy. Energy Diagram. Stable and Unstable Equilibrium. Gravitational Potential Energy. Elastic Potential Energy. Force as Gradient of Potential Energy. Work and Potential energy. Work done by Non-conservative Forces. Law of Conservation of Energy. Elastic and Inelastic Collisions between particles. Centre of Mass and Laboratory Frames.

Unit-II

Rotational Dynamics: Angular Momentum of a Particle and System of Particles. Torque. Conservation of Angular Momentum. Rotation about a Fixed Axis. Moment of Inertia. Calculation of Moment of Inertia for Rectangular, Cylindrical, and Spherical Bodies. Kinetic Energy of Rotation. Motion involving both Translation and Rotation.

Unit-III

Elasticity: Coefficients of elasticity. Young's Modulus by different methods. Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder Determination of Rigidity modulus by static torsion–Torsional pendulum.

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. Bernoulli's Law. Equation of Continuity. Navier Stokes's equation. Motion of viscous fluids.

Unit-IV

Gravitation and Central Force Motion: Law of gravitation. Inertial and Gravitational Mass.

Potential and Field due to Spherical Shell and Solid Sphere.

Motion of a Particle under 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 (Ideas Only). Orbits of Artificial Satellites.

Suggested Readings:

1. Daniel Kleppner, Robert J. Kolenkow, An introduction to Mechanics, McGraw-Hill (1973).
2. Charles Kittel, Walter Knight: Malvin Ruderman, Carl Helmholz, Burton Moyer, Mechanics, Vol. 1, Berkeley Physics Course, McGraw Hill (2007).
3. F.W. Sears, M.W. Zemanski and H.D. Young, University Physics. Addison-Wesley (1986).
4. D. S. Mathur, Mechanics, S. Chand & Company Limited (2000).
5. P.S. Hemne and D. S. Mathur, Mechanics, S. Chand & Company Limited (2000).
6. Schaum's Outline of Beginning Physics-I: Mechanics and Heat, McGraw Hill (2020).

COURSE OUTCOMES (Mechanics and Properties of Matter)

CO-1 Students will understand the vectorial and scalar representation of forces and moments.

CO-2 Student will describe static equilibrium of particles and rigid bodies both in two dimensions and also in three dimensions.

CO-3 Students will be able to analyze properties of surfaces & solids in relation to moment of inertia.

CO-4. Students will illustrate the laws of motion, kinematics of motion and their inter-relationship.

CO-5. Students will be able to comprehend the effects of Friction on general plane motion.

PHY-MP-103: Mechanics Lab Credit(s): 1

N.B.: Students are required to perform at least 6 experiments

1. To Verify Lami's Theorem.
2. To verify Polygon law of forces.
3. To verify Law of Parallelogram of Forces.
4. To determine the Young's Modulus using Bar method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine Support Reactions of a Simply Supported Beam.
8. To measure coefficient of Static Friction.
9. To determine moment of inertia of a flywheel about its own axis of rotation.
10. To determine velocity of sound in air by using speaker, microphone and CRO.
11. Study of the random decay and determination of decay constant using statistical board.

PHY-SECT-104: Computational Physics-I Credit(s): 2

Unit-I

Introduction to Power Point Presentation Techniques. Introduction to Equation Editor in MS Word.

Introduction to Excel Sheet Techniques. Introduction to LaTeX file preparation.

Mathematical symbols and commands, Arrays, formulas, and equations, spacing, borders and colors, using date and time option in LaTeX, to create applications and letters, beamer (PPT in Latex). Preparation of an article in LaTeX. Inserting pictures and graphics in LaTeX.

Unit-II

Introduction to Programming in C Language: Types of Languages, Evolution of 'C' Language. Structure of a 'C' Program, 'C' Program development life cycle. Executing and Debugging a 'C' Program.

Programming in 'C'-'C' Tokens: Keywords and Identifiers, Operators, Constants, Variables, Data Types, Precedence of Operators, Scope and Lifetime of Variables.

Unit-III

Programming in 'C'- Control Statement and Expressions and Looping: Decision Making using if statement, Types of if …else block, Switch case Block, Arithmetic Expressions, Evaluation of Expressions, GOTO statement, Concept of Loop, For loop, While loop, Do while loop, Jumping in Loop break, and continue statement.

***Suggested Readings*:**

1. Yashwant Kanetkar, **Let Us C**, BPB Publications (2020).

2. E. Balagurusami, **Programming in ANSI C**, McGraw Hill (2018).

COURSE OUTCOMES OF COURSE ON- COMPUTATIONAL PHYSICS-I

Upon completion of this course, students would be able to:

CO1. Learn basic skills of **Power Point Presentation/Multimedia** and **Excel** techniques and practice them.
CO2. Apply Monte Carlo method and other simulation methods to solve deterministic as well as probabilistic physical problems.

CO3. Employ appropriate numerical method to interpolate and extrapolate data collected from physics experiments.

CO4. Use appropriate numerical method to solve the differential equations governing the dynamics of physical systems

CO5. Formulate and computationally solve a selection of problems in physics, use the tools, **Programming Language C** and conventions of physics to test and communicate ideas and explanations.

PHY-SECP-104: Computational Physics Lab-I Credit(s): 1

A student is required to perform at least eight exercises from the following **(and not limited to)**:

1. To write a program in C language to perform input/output of all basic data types.

2. To write a program in C language to prepare and draw once family tree.

3. To write a program in C language to enter two numbers and perform all arithmetic operations.

4. To write a program in C language to convert days into years, weeks and days and prepare a calendar.

5. To write a program in C language for the interconversion of various physical units.

6. To write a program in C language to find surface area and volume of objects with various shapes.

7. To write a program in C language to calculate mean, median and mode of the given data.

8. Write a program in C language to find roots of a quadratic equation.

9. Write a C program to enter P, T, R, and calculate Simple and Compound Interest.

Suggested Readings:

1. Yashwant Kanetkar, **Let Us C**, BPB Publications (2020).

2. E. BalaGurusami, **Programming in C**, McGraw Hill (2018).

PHY-MI-102: Mechanics (Physics Minor-I) Credits: 2

Unit-I: Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(4 Lectures)**

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. Direct and oblique collisions. **(4 Lectures)**

Unit-II

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(4 Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. **(6 Lectures)**

Unit-III

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(4 Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire. **(4 Lectures)**

Suggested Readings:

1. F.W. Sears, M.W. Zemanski and H.D. Young, University Physics. Addison-Wesley (1986).
2. Charles Kittel, Walter Knight, Malvin Ruderman, Carl Helmholz, Burton Moyer, Mechanics, Vol. 1, Berkeley Physics Course, McGraw Hill (2007).
3. D. S. Mathur, Mechanics, S. Chand and Company Limited (2000).
4. P.S. Hemne and D. S. Mathur, Mechanics, S. Chand & Company Limited (2000).
5. Schaum's Outline of Beginning Physics-I: Mechanics and Heat, McGraw Hill (2020).

PMS-MDC-100: Logic and Computability Credits-03

(Computable Mathematical Physics-I)

Unit–I

Logic and Sets Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contrapositive and inverse propositions, and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables, and Negations.

Unit–II

Sets, subsets, Set operations, the laws of set theory, and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. The empty set, properties of the empty set. Standard set operations. Classes of sets. The power set of a set.

Unit-III

Difference and Symmetric difference of two sets. Set identities, Generalized unions, and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with the example of congruence modulo relation.

Duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sub-lattices, products, and homomorphisms.

UNIT – IV

Definition, examples, and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits. Introduction to Machine Learning (2 Lectures).

***Suggested Readings*:**

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education (1998).

2. P.R. Halmos, Naive Set Theory, Springer (1974).

3. E. Kamke, Theory of Sets, Dover Publishers (1950).

Semester-II

PHY-MT-203: Waves and Oscillations **Credit(s): 3**

Unit-I

Oscillations in Arbitrary Potential Well: Simple Harmonic Oscillations. Differential Equation of SHM and its Solution. Amplitude, Frequency, Time Period and Phase. Velocity and Acceleration. Kinetic, Potential and Total Energy and their Time Average Values. Reference Circle. Rotating Vector Representation of SHM.

Free Oscillations of Systems with One Degree of Freedom: (1) Mass-Spring system, (2) Simple Pendulum, (3) Torsional Pendulum, (4) Oscillations in a U-Tube, (5) Compound pendulum: Centres of Percussion and Oscillation, and (6) Bar Pendulum.

Unit-II

Driven Oscillations: Damped Oscillations: Damping Coefficient, Log Decrement. Forced Oscillations: Transient and Steady States, Amplitude, Phase, Resonance, Sharpness of Resonance, Power Dissipation and Quality Factor. Helmholtz Resonator.

Coupled Oscillators: Normal Coordinates and Normal Modes. Energy Relation and Energy Transfer. Normal Modes of N Coupled Oscillators.

Unit-III

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:

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.

Unit-IV

Elastic Waves in Solid Rod. Pressure Waves in Glass Columns. Transverse Waves in Strings. Waves in Three Dimensions. Spherical Waves. Plane Electromagnetic Waves. Energy and Momentum of Plane EM Waves. Radiation Pressure. Radiation Resistance of free space. EM Waves in dispersive Media. Spectrum of EM Waves.

Unit-IV

Ultrasonics: Production of ultrasonic waves. Echo; Reverberation, reverberation time, Sabine‟s formula, remedies over reverberation; Absorption of sound, absorbent materials; Conditions for good acoustics of a building; Noise, its effects and remedies. **Piezoelectric effect**. Detection of ultrasonic waves: Piezoelectric detector. Kundt's tube method. Sensitive flame method. Thermal detector method. Properties of ultrasonic waves. Cavitation. Acoustic grating. Velocity measurements.

SONAR: Non-destructive testing. Pulse echo technique. Transmission technique. Resonance.

Medical Applications: Echocardiograms/Sonogram. Ultrasonic Imaging (ScanDisplay).

Suggested Readings:

1. A. P. French, Vibrations and Waves, CBS Pub. & Dist. (1987).

2. K. Uno Ingard, Fundamentals of Waves & Oscillations, Cambridge University Press (1988).

3. Daniel Kleppner and Robert J. Kolenkow, An Introduction to Mechanics, McGraw-Hill (1973).

4. Franks Crawford, Waves, BERKELEY PHYSICS COURSE (SIE), Tata McGraw Hill (2007).

5. M. S. Seymour Lipschutz, Schaum's Outline of Vector Analysis, McGraw-Hill (2009).

6. D. E. Bourne, P C Kendall, Vector Analysis and Cartesian Tensors, Chapman & Hall (1994),

COURSE OUTCOMES: WAVES AND OSCILLATIONS

CO-1 Oscillations, waves and wave equation to find out the relationship between the speed of propagation of waves and the physical properties of the string.

CO-2 To understand how stationary / standing waves are produced by the superposition of incident and reflected waves in string fixed at the both ends.

CO-3 Know the different modes of vibrating in the string and find out how different harmonics can be produced.

CO-4 Understand and be able to derive and solve the equations for a forced oscillator; understand the concept of resonance and the response of a system (amplitude and phase, power dissipation) as a function of driving frequency and the effects of transients.

CO-5Understand the basic concept of ultrasonic.

PHY-MP-203: Mechanics Lab-II Credit(s): 1

N.B.: Students are required to perform at least 06 experiments

1. To determine the Young's Modulus.
2. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
3. To determine the Elastic Constants of a Wire by Searle's method.
4. To verify Law of Parallelogram of Forces.
5. To verify Polygon law of forces.
6. To determine Support Reactions of a Simply Supported Beam.
7. To measure coefficient of Static Friction.
8. To Verify Lami's Theorem.
9. To determine moment of inertia of a flywheel about its own axis of rotation.
10. To determine the coefficient of discharge of Venturimeter.
11. To determine the coefficient of discharge, contraction & velocity of an orifice.
12. To verify the Bernoulli's Theorem.
13. Determination of velocity of sound in air by using speaker, microphone and CRO.
14. Study of the random decay and determination of decay constant using statistical board.

COURSE OUTCOMES OF MECHANICS LAB

CO-1 Apply knowledge of Elasticity to explain natural physical processes.

CO-2 Use an understanding of Modulus further study in science.

CO-3 Design experiments and acquires data in order to explore physical principles, effectively communicate results, and critically evaluate related scientific studies.

CO-4 Assess the contributions of physics using Parallelogram of Forces.

PHY-SECT-204: Computational Physics-II Credit(s): 2

Unit-I

Introduction to Programming in C^{++}: Basic concept of Object-Oriented Programming (OOP), Comparison of Procedural Programming and OOP, Benefits of OOP, C^{++} compilation, Abstraction, Encapsulation, Inheritance, Polymorphism, Difference between C and C^{++}. Tokens and identifiers: Character set and symbols, Keywords, C^{++} identifiers; Variables and Constants: Integer, character and symbolic constants.

Operators, Manipulators Decision and Control Structures Programming in C^{++}:

Operators and Manipulators Operators, Types of operators in C^{++}, Precedence and associativity of operators, Manipulators. if statement, if-else statement, switch statement, Loop: while, do-while, for; Jump statements: break, continue, go to.

Unit-II

Array, Pointer, Structure and Functions

Arrays, pointers, structures, unions; main () function, components of function: prototype, function call, definition, parameter; passing arguments; types of function, inline function, function overloading.

Mathematica: Basic introduction: Arithmetic operations, functions, graphics: 2-D plots, 3-D plots, plotting the graphs of different functions, matrix operations, finding roots of an equation, finding roots of a system of equations, solving differential equations. Solving physics problems by using Mathematica commands and codes.

Unit-III

Introduction to MATLAB: Basic Introduction: Simple arithmetic calculations, creating and working with arrays, numbers, and matrices, creating and printing simple plots, function files, basic 2-D plots, and 3-D plots. Solving physics problems by using MATLAB codes.

***Suggested Readings*:**

1. Andi Klein and Alexander Godunov**,** Introductory Computational Physics **(2006)**.
2. Rubin H. Landau, José Páez and Cristian C. Bordeianu and A Survey of Computational Physics: Introductory Computational Science, Princeton University Press (2008).
3. Amos Gilat, MATLAB: An Introduction, Wiley (2013).
4. Rudra Pratap, MATLAB: A Quick Introduction, Oxford University Press (2010).

COURSE OUTCOMES OF COURSE ON COMPUTATIONAL PHYSICS-II

Upon completion of this course, students would be able to:

CO1. Demonstrate knowledge in essential methods and techniques for numerical computation in physics.

CO2. Formulate and computationally solve a selection of problems in physics, use the tools, language **C^{++}** and conventions of physics to test and communicate ideas and explanations.

CO3. Formulate and computationally solve a selection of problems in physics, use the tools of **MATLAB**.

CO4. Formulate and computationally solve a selection of problems in physics, use the tools of ***Mathematica***.

CO5. Use appropriate numerical method to solve the differential equations governing the dynamics of physical systems.

PHY-SECP-204: Computational Physics Lab-II Credit(s): 1

Students are required to perform at least eight exercises from the following (and not limited to):

1. To write a program in C^{++} to display various arithmetic operations using mixed data type.
2. To write a program in C^{++} to display the operation of pre and post increment and decrement.
3. To write a program in C^{++} to convert temperature in Kelvin to Celsius

4. To write a program in C^{++} that converts kilometers per hour to miles per hour. Write a program in C^{++} to compute quotient and remainder.

To write programme on the following problems using MATLAB or Mathematica:

5. To solve ordinary differential equations.

6. To evaluate integrals of various types.

7. To find matrix eigen values. The problem of finding eigen values of very large matrices, and their corresponding eigenvectors (eigen states in quantum physics).

8. To understand Molecular dynamics by computation and plot Geometry of atomic orbitals.

9. To understand Computational Fluid Dynamics and solve Navier Stoke's and Bernoulli's equation.

10. To solve Magneto-Hydrodynamics (MHD) equation by computation.

***Suggested Readings*:**

1. Andi Klein and Alexander Godunov, Introductory Computational Physics **(2006)**
2. Rubin H. Landau, José Páez and Cristian C. Bordeianu and A Survey of Computational Physics: Introductory Computational Science, Princeton University Press (2008).
3. Amos Gilat, MATLAB: An Introduction, Wiley (2013).
4. Rudra Pratap, MATLAB: A Quick Introduction, Oxford University Press (2010).

PHY-MI-202: Electricity and Magnetism (Physics Minor-II) Credits-2

Unit-I

Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(10 Lectures)**

Unit-II

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic fields. Dielectric medium, Polarization and Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(5 Lectures)**

Magnetism: Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-, and ferro-magnetic materials. **(5 Lectures)**

Unit-III

Electromagnetic Induction: 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. **(4 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: 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. **(6 Lectures)**

***Suggested Readings*:**

1. Edward M. Purcell, Electricity and Magnetism, McGraw-Hill Education (1986).

2. J.H. Fewkes & J. Yarwood, Electricity & Magnetism, Vol. I, Oxford Univ. Press (1991).

3. D C Tayal, Electricity and Magnetism, Himalaya Publishing House (1988).

4. Ronald Lane Reese, University Physics, Thomson Brooks/Cole (2003).

5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Ed, Benjamin Cummings (1998).

PMS-MDC-200: Data Analytics and Statistics Credits-03

(Computable Mathematical Physics-II)

Unit I: Introduction

Data science and big data; structured data, unstructured data, natural language, machine generated data, graph based or network data, audio, image and video data, streaming data; process; big data ecosystem and data science; Hadoop.

Method of collection; methods of presentation; graphic presentation; rates, ratios and percentages; frequency distributions, frequency curves, types of frequency distributions; Describing frequency distribution by a fitted curve.

Unit II: Analysis Techniques

Quantitative analysis; qualitative analysis; data mining; statistical analysis: A/B testing, correlation, regression.

Measures of central tendency, dispersion, skewness and kurtosis based on moments; median, mode, weighted and unweighted geometric mean and harmonic mean; range, mean deviation.

Unit III: Statistical Techniques and Inferences

Bivariate data, scatter diagram, correlation, correlation coefficient: properties, method of least squares and simple linear regression; polynomial regression; correlation index, correlation ratio.

Tests of hypothesis based on t-distribution: a single population mean/proportion, the difference between two population means/proportions, paired comparisons.

Unit IV: Probability and Inferences

Probability, conditional probability, discrete random variables, random walks, Markov chains: states and transitions, general two-state Markov chain, transition matrix, powers of general transition matrix, classification of states, classification of chains. **The idea of machine learning (2 lectures only)**.

Suggested Readings:

1. Cielen, D., Meysman, D. B. and Ali, M., Introducing Data Science, Dream Tech Press (2018).

2. Erl, T., Khattak, W. and Buhler, P., Big Data Fundamentals: Concepts, Drivers and Techniques, Pearson (2016).

3. Jones, P. W. and Smith, P., Stochastic Processes: An Introduction, CRC Press (2017).

4. Rao, A. R. and Bimasankaram, P., Linear Algebra, Springer (2000).

Semester-III

PHY-MT-301: Electricity and Magnetism **Credit(s): 3**

Unit-I

Electric Field and Electric Potential: Electric Field: Electric Field and Lines. Electric Field **E** due to a Ring of Charge. Electric Flux. Gauss's law. Gauss's law in Differential form. Applications of Gauss's Law: **E** due to (1) an Infinite Line of Charge, (2) a Charged Cylindrical Conductor, (3) an Infinite Sheet of Charge and Two Parallel Charged Sheets, (4) a Charged Spherical Shell, (5) a Charged Conducting Sphere, (6) a Uniformly Charged Sphere, (7) Two Charged Concentric Spherical Shells and (8) a Charged Conductor. Force on the Surface of a Charged Conductor and Electrostatic Energy in the Medium surrounding a Charged Conductor.

Unit-II

Electric Potential: Line Integral of Electric Field. Electric Potential Difference and Electric Potential V (Line integral). Conservative Nature of Electrostatic Field. Relation between **E** and V. Electrostatic Potential Energy of a System of Charges. Potential and Electric Field of (1) a Dipole, (2) A Charged Wire and (3) A Charged Disc. Force and Torque on a Dipole. Conductors in an Electrostatic Field. Description of a System of Charged Conductors. An Isolated Conductor and Capacitance. Method of Images and its Application to: (1) Plane Infinite Sheet and (2) Sphere. **Electrostatic Energy** of (1) A Point Charge; (2) A System of Point Charges; (3) A Uniform Sphere; and (4) A Capacitor.

Unit-III

Dielectric Properties of Matter: Dielectrics: Electric Field in Matter. Dielectric Constant. Parallel Plate Capacitor with a Dielectric. Polarization, Polarization Charges and Polarization Vector. Electric Susceptibility. Gauss's law in Dielectrics. Displacement vector **D**. Relations between the three Electric Vectors. Capacitors filled with Dielectrics.

Unit-IV

Magnetic Field: Magnetic Effect of Currents: Magnetic Field **B**. Magnetic Force between Current Elements and Definition of **B.** Magnetic Flux. Biot-Savart's Law: **B** due to (1) a Straight Current Carrying Conductor and (2) Current Loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital law (Integral and Differential Forms): B due to (1) a Solenoid and (2) a Toroid. Properties of **B.**

Forces on an Isolated Moving Charge. Magnetic Force on a Current Carrying Wire. Torque on a Current Loop in a Uniform Magnetic Field.

Electromagnetic induction: Faraday's law (Differential and Integral forms). Lenz's Law. Self and Mutual Induction. Energy stored in a Magnetic Field. Maxwell's equations.

***Suggested Readings*:**

1. Edward M. Purcell: Electricity and Magnetism, McGraw-Hill Education (1986).

2. Arthur F. Kip: Fundamentals of Electricity and Magnetism, McGraw-Hill (1968).

3. J. H. Fewkes & John Yarwood: Electricity & Magnetism, Oxford Univ. Press (1991).

4. David J. Griffiths: Introduction to Electrodynamics, Benjamin Cummings, (1998) (Also, PHI).

COURSE OUTCOMES OF ELECTRICITY AND MAGNETISM

Upon completion of this course, students would be able to:

CO-1. Apply knowledge of electricity and magnetism to explain natural physical process and related technological advances.

CO-2. Use understanding of calculus along with physical principles to effectively solve problems encountered in everyday life, further study in science, and in the professional world.

CO-3. Design experiments and acquire data in order to explore physical principles, effectively communicate results, and critically evaluate related scientific studies.

CO-4. Assess the contributions of Physics to our evolving understanding of global change and sustainability while placing the development of Physics.

PHY-MT-303: Mathematical Methods in Physics: Differential Equations Credit(s): 4

Unit-I

First-order exacts differential equations, integrating factors, rules to find an integrating factor, first-order higher degree equations solvable for x, y, and p, Methods for solving higher-order differential equations.

Unit-II

Basic theory of linear differential equations, Wronskian, and its properties, solving a differential equation by reducing its order, Linear homogenous equations with constant coefficients, and Linear non-homogenous equations.

Unit-III

The method of separation of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Unit-IV

Order and degree of partial differential equations, Concept of Linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method.

Unit-V

Charpit's method, Classification of second-order partial differential equations into elliptic, parabolic, and hyperbolic through illustrations only.

Suggested Readings:

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons (1984).
2. T. Amarnath, An Elementary Course in Partial Differential Equations, (2nd edition), Narosa Publishing House (1997).
3. Phoolan Prasad, Renuka Ravindran, Partial Differential Equations, New Age International Publication, New Delhi (2009).
4. Ian N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Company, New York (1957).
5. L.C. Evans, Partial Differential Equations, Graduate studies in Mathematics, Vol 19, AMS (1998).
6. F. John, Partial Differential Equations, 3rd ed. Narosa Publ. Co., New Delhi (1979).
7. M.D. Raisinghania, Ordinary and partial differential equations, S. Chand Publishing, New Delhi (2017).
8. R.K. Gupta, Partial Differential Equations, Krishna Prakashan, Meerut (2014).
9. Video lecture on ordinary differential equation of first order-Exact differential equation Link https://www.youtube.com/watch?v=suvzwN2Df7k
10. Video lecture on Partial Differential Equation - Charpit Method for Non Linear PDE Link https://www.youtube.com/watch?v=2_hfp8JPP30

PHY-MP-301: Electricity and Magnetism Lab Credit(s): 1

N.B.: Students are required to perform at least 10 experiments

1. To use a Multimeter for measuring:

(a) Resistances, (b) A/C and DC Voltages, (c) AC and DC Currents, (d) Capacitances, and (e) Frequencies.

2. To convert a **Galvanometer into an Ammeter** of given range and calibrate it.

3. To convert a **Galvanometer into a Voltmeter** of given range and calibrate it.

4. To determine **specific Resistance** of a wire by **Carrey-Foster's Bridge**.

5. To determine radius of a current carrying coil using **Tangent Galvanometer**.

6. To study **LCR circuit** characteristics.

7. To study **L-C transmission Line** and determine **attenuation coefficient**.

8. To study **R-C transmission Line** and determine **attenuation coefficient**.

9. To determine an unknown resistance using ***de-Sauty Bridge***.

10. To determine an unknown resistance using ***Anderson Bridge***.

11. To study charging and discharging of a capacitor and determine time constant.

12. Determination of value of Earth's magnetic field (B-H) using Tangent Galvanometer.

13. To determine the magnetic field along an axis passing through the centre of current carrying coil using Tangent Galvanometer.

Suggested Readings:

1. Geeta Sanon: B.Sc. Practical Physics, 1st Ed. (2007), R. Chand & Co.

2. B. L. Worsnop and H. T. Flint: Advanced Practical Physics, Asia Publishing House, New Delhi.

3. Indu Prakash and Ramakrishna: A Text Book of Practical Physics, Kitab Mahal, New Delhi.

4. D. P. Khandelwal: A Laboratory Manual of Physics for Undergraduate Classes, Vani Publ.

PHY-SECT-304: Solar Energy and Energy Studies Credit(s): 3

Unit-I

Heat conduction: Differential equation of heat conduction, Initial and boundary conditions. methods of solving heat conduction problems: separation of variable method for one dimension, steady and non-steady state method: Theory and measurement of thermal conductivity and thermal diffusivity by transient plane source techniques.

Unit-II

Convective Heat Transfer: Theory of convective heat transfer, Laminar and turbulent flow, Boundary layer theory. Heat transfer in duct.

Characteristics of solar Radiation: Solar radiation at the earth surface, direct, diffuse and global radiation, Elements of solar radiations geometry, empirical equations for predicting the availability of solar radiations, computation of insolations on a tilted surface. Atmospheric attenuation, solar radiation measurements.

Unit-III

Flat Plate solar collectors: Selective absorber surfaces. Transparent plates. Collector energy losses. Thermal analysis of flat plate water and air heating collectors. Collector performance testing. Simple appliances working with flat plate collectors: solar cooker; water heater, air dryer and stills.

Concentrating collectors: Optical concentration, flat plate collectors with plane reflectors, cylindrical parabolic concentrating collectors. Tracking requirements.

Unit-IV

Thermal Energy Storage and Solar Thermal Devices: Water storage. Stratification of water storage, Packed bed storage. Phase change storage. Chemical storage. Solar pond. Economics of solar energy appliances. Efficiencies in different storages. Space conditioning.

Solar space conditioning: Energy requirements in buildings, Performance and design of Passive system architecture, Absorption refrigeration cycle, Performances of solar absorption air conditioning.

Essentials of wind energy: Classifications and Description of Wind machines. Performances of wind machine (solidity factor Y(Lambda); Energy in the wind.

Suggested Readings:

1. David W. Hahn, M. Necati Özişik , Heat Conduction, John Wiley & Sons (2012).

2. Warren, M., Rohsenow, W.M., James, P. Hartnett and Ejup N. Ganic,
Hand Book of Heat Transfer Application (Edited), (1998).

3. H.S., Carlas and J.C. Jaegar, Conduction of Heat in Solids, Oxford Clarendon Press (1959).

4. A Luikov, Heat and Mass Transfer, Mir Publishers Moscow (English, 1980).

5. J.E. Parrot and Audrey D. Stuckers, Thermal Conductivity of Solids, Pion Limited, London (1975).

6. Duffie and Backman, Solar energy Thermal Process, Wiley & Sons. New York (2013).

7. Jui Sheng Hsieh, Solar Energy Engineering, Prentice Hall, New Jersey (1921).

11. Martin A. Green, Solar Cells: Operating principles, Technology and System Applications, Prentice-Hall Inc, Englewood Cliffs, NJ, USA (1981).

12. J. Poortmans J and Vladimir Akhipov, Thin Film Solar Cell: Fabrication, Characterizations and Applications, John Wiley & Sons, England (2006).

Course Outcome (CO) of Solar Energy and Alternative Sources of Energy

Upon completion of this course, students would be able to:

CO-1: Understand the principles of various natural phenomena and skills to tap **solar energy**.

CO-2: Learn the technologies that are used to harness the power of solar energy.

CO-3: Analyse the positive and negative aspects of solar energy in relation to natural and human aspects of the environment.

CO-4: Apply and design the solar devices and different types of collectors.

CO-5: Analyze the different modes of energy transfer in various natural phenomena.

PHY-MI-302: Thermodynamics (Physics Minor-III) Credits: 2

Unit-I

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various

Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law of Thermodynamics. **(10 Lectures)**

Unit-II

Entropy: Entropy, Carnot's cycle and theorem. Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute

Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(10 Lectures)**

Unit-III

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocitiesand 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. **(5 Lectures)**

Theory of Radiation: 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 Lectures)**

Suggested Readings:

1. Meghnad Saha, and B.N. Srivastava, A Treatise on Heat, Indian Press (1969).

2. Enrico Fermi, Thermodynamics, Courier Dover Publications (1956).

3. M.W. Zemasky and R. Dittman, Heat and Thermodynamics, McGraw Hill (1981).

4. F.W. Sears and G.L. Salinger, Thermodynamics, Kinetic theory & Statist. Thermodynamics, Narosa (1988).

5. Ronald Lane Reese, University Physics, Thomson Brooks/Cole (2003).

6. Brij Lal, N. Subramanyam, P.S. Hemley, Heat Thermodynamics and Statistical Physics, S. Chand (2019).

PMS-MDC-300: Computable Graph Theory Credits-03

(Computable Mathematical Physics-III)

Unit-I

Introduction to graphs, Basic properties of graphs, Complete and bi-partite graphs, Isomorphism, Paths and circuits, Eulerian Graphs, Hamiltonian cycles, Directed Graphs (or Digraphs), Perfect Graphs, Matrix representation of graphs, Vertex estimation of Graphs, Chordal graphs, Weighted graphs,

Unit- II

Matchings in graphs, Hall's 'marriage' theorem and its application, Travelling salesman's problem & Chinese postman problem, Planar graphs, Euler's formula, Distances in graphs, Shortest path and Dijkstra's algorithm, Floyd – Warshall Algorithm, Bellman-Ford Algorithm.

Unit-III

Trees, Spanning trees in graphs, Minimum spanning tree algorithms, Kruskal's algorithm
Independence sets and covering in graphs. Cut vertices and Cut edges, Edge connectivity,

UNIT-IV

Vertex Colouring of graphs. Edge Colouring of graphs. Four-colour and five-colour theorems. Applications of graphs in switching theory. Mathematica based Computation of Graphs. Partitions of Graphs. Graph Fusion Techniques. Graph Networks.

Suggested Readings:

1. J. A. Bondy, and U.S.R. Murty, "Graph Theory", Springer-Verlag (2008).
2. R. DIESTEL, "Graph Theory", Springer-Verlag (1997).
3. F. HARARY, "Graph Theory", Addison-Wesley (1969).
4. D.B. WEST, "Introduction to Graph Theory", Prentice Hall (1996).
5. R.J. WILSON, "Introduction to Graph Theory", Longman, (3rd ed. 1985)

Semester-IV

PHY-MT-401: Thermodynamics **Credit(s): 4**

Unit-I

Second Law of Thermodynamics: Reversible and Irreversible Changes. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot Cycle. Carnot Engine and its Efficiency. Refrigerator and its Efficiency. Second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit-II

Entropy: Change in Entropy. Entropy of a State. Clausius Theorem. Clausius Inequality. Second Law of Thermodynamics in terms of Entropy. Entropy of a Perfect Gas. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Impossibility of Attainability of Absolute Zero: Third Law of Thermodynamics. Temperature-Entropy Diagrams. First and second order Phase Transitions.

Unit-III

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials U, H, F and G: Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work. Cooling due to Adiabatic Memagnetization. Approach to Absolute Zero.

Unit-IV **Kinetic Theory of Gases:** Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment.

Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific Heats of Gases.

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

Unit-V

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 Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

Phase Transitions.

***Suggested Readings*:**

1. Enrico Fermi, Thermodynamics, Courier Dover Publications (1956).
2. Meghnad Saha, and B.N. Srivastava, A Treatise on Heat, Indian Press (1969).
3. M.W. Zemasky and R. Dittman, Heat and Thermodynamics, McGraw Hill (1981).
4. F.W. Sears and G.L. Salinger, Thermodynamics, Kinetic theory & Statistical Thermodynamics, Narosa (1988).
5. Ronald Lane Reese, University Physics, Thomson Brooks/Cole (2003).
6. Claus Borgnakke and Richard E Sonntag, Fundamentals of Thermodynamics 8th Edition, Wiley India Edition (2020).
7. Yunus A. Cengel, Michael A. Boles, and Mehmet Kanoglu, Thermodynamics- An Engineering Approach, (9th Edition), Tata McGraw Hill publications (2019).
8. J. B. Jones and G. A. Hawkins, Engineering Thermodynamics, John Wiley and Sons (1986).
9. Brij Lal, N. Subramanyam & P.S. Hemley, Heat Thermodynamics and Statistical Physics, S. Chand (2019).
10. Y. V. C. Rao, An Introduction to Thermodynamics, Wiley Eastern (2003).
11. V Kadambi and T R Seetharam, Applications of Thermodynamics, Wiley Publications (2018).

COURSE OUTCOMES OF THERMODYNAMICS

Upon completion of this course, students would be able to:

CO-1. Understand and correctly use thermodynamic terminology.

CO-2. Define the concepts of heat, work, and energy.

CO-3. Explain fundamental thermodynamic properties.

CO-4. Develop the General Energy Equation.

CO-5. Derive and discuss the first law of thermodynamics**.**

PHY-MT-403: Solid State Electronics   Credit(s): 4

Unit-I

Circuit Analysis: Kirchhoff's Laws, Mesh and Node Analysis of dc and ac Circuits, Duality in Networks. Network Theorems. Norton's Theorem. Thevenin's Theorem. Equivalent Star (T) and delta (π) Networks of a Given Network, Star to Delta and Delta to Star Conversion. Wheatstone Bridge and its Applications to Wein Bridge and Anderson Bridge.

Unit-II

Band Theory. Conductors, semiconductors, insulators. Theory of semi-conductors.

Semiconductor Diodes: p and n Type Semiconductors. Energy Level Diagram. Conductivity and Mobility. P-N Junction Fabrication (Simple Idea). Barrier Formation in pn Junction Diode. Current Flow Mechanism in Forward and Reverse Biased Diode (Recombination, Drift and Saturation of Drift Velocity). Derivation of Mathematical Equations for Barrier Potential, Barrier Width and Current for Step Junction. P-N junction and its characteristics.

Zener diode characteristics.

Unit-III

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. Qualitative idea of C, L and π - Filters. (2) Zener Diode and Voltage Regulation. (3) Photo Diode, (4) Tunnel Diode, (5) LED (6) Varactor Diode.

Unit-IV

Bipolar Junction transistors: NPN and PNP Transistors. Characteristics of CB, CE and CC Configurations. Current gains α, β and γ and Relations between them. Load Line Analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff, and Saturation Regions. Transistor in Active Region and Equivalent Circuit.

Unit-V

Amplifiers. Oscillators. Transistor as amplifier. Amplification and gain characteristics. Feed-back amplifiers. Hartley oscillator. Colpitts' oscillator.

Radio Transmission and Reception. Modulation and demodulation of electromagnetic waves. Frequency and amplitude modulation. Transmission circuits. Superheterodyne receiver circuit.

***Suggested Readings*:**

1. David J. Griffiths, Introduction to Electrodynamics, Benjamin Cummings, 1998 (Also, PHI).

2. Arthur Beiser, Prospects in Modern Physics, McGraw-Hill Book Company (1998).

3. Charles Kittel, Introduction to Solid State Physics, 7th Edition, John Wiley and Sons, Inc.

4. A. J. Dekkar, Solid State Physics, Macmillan India Limited, 2000.

5. A. P. Malvino, Electronic Principals, Glencoe, 1993.

6. Allen Mottershead, Electronic Circuits and Devices, PHI, 1997.

Course Outcome (CO) of Solid State Electronics

Upon completion of this course, students would be able to:

CO1. Have an understanding of various properties of solids and lattice vibrations.

CO2. Develop understanding of properties of metals on the basis of Solid State Physics models.

CO3. Have an understanding of the essence of dielectric properties of materials.

CO4. Have an understanding of the structural properties of solids and the relation to their electronic properties.

CO-5. Students understand the factors that influence the flow of charge in semiconductors.

CO-6. Students able to describe the operation of semiconductor devices.

PHY-MT-404: Optics and Photonics Credit(s): 4

Unit-I

Classical Photometry: Introduction. **(2 Lectures)**

Geometrical Optics (Wave Optics)
Nature of Light: Theories of Light. Electromagnetic Nature of Light Definition of a Wave Front. Propagation of a Wave Front. Huygens Principle of Secondary Wavelets. Introduction to interference. Introduction to Diffraction. **(6 Lectures)**

Interference: Interference: Division of Amplitude and Division of Wavefront. Interference in Thin Films: Parallel and Wedge-shaped Films. Newton's Rings: Measurement of Wavelength and Refractive Index. **Michelson's Interferometer**: (1) Idea of form of fringes (No Theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, (5) Standardization of Meter and (6) Visibility of Fringes. **(6 Lectures)**

Unit-II

Diffraction: 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. Comparison of a Zone plate with a Convex lens.

Fraunhoffer diffraction: Diffraction due to (1) a Single Slit, (2) a Double Slit and (3) a Plane Transmission Grating. Rayleigh's criterion of resolution. Resolving Power and Dispersive Power of a Plane Diffraction Grating. Bragg's Law. **(12 Lectures)**

Unit-III

Polarization: The idea of polarization. Double refraction. Calcite crystals. Nicole prism.

Optical Rotations: Optical rotations. Specific rotation. Levo- and dextro-rotations. Circularly and elliptically polarized light.

Polaroids. Applications of concept of Polarization. **(12 Lectures)**

Unit-IV

Coherence: Spatial and temporal coherence, Coherence length, Coherence time. Q-factor for LASER. Visibility as a Measure of Coherence. Spatial Coherence and Size of the Source. Temporal Coherence and Spectral Purity. **(6 Lectures)**

LASER: Theory of LASER action: Einstein's coefficients, Threshold conditions for LASER Action. Method and Mechanism of production of He-Ne LASER. Semiconductor LASER. Elementary ideas of Q-switching and Mode Locking. LASER Diodes. LEDs. Optical Sensors. **(6 Lectures)**

Unit-V

Holography: Holography versus photography. Basic theory of Holography. Applications of Holography in Microscopy and Interferometry. **(4 Lectures)**

Optical Communication: Optical fiber as optical wave-guide. Numerical Aperture and Maximum Angle of Acceptance. Types of Optical Fibers. **(8 Lectures)**

***Suggested Readings*:**

1. F. A. Jenkins and Harvey Elliott White: Fundamentals of Optics, McGraw-Hill, 1976.

2. Ajoy Ghatak: Optics, Tata McGraw Hill, 2008.

3. Eugene Hecht and A R Ganesan: Optics, Pearson Education, 2002.

4. A. K. Ghatak & K. Thyagarajan: Contemporary Optics, Plenum Press, 1978.

5. S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, 1st ed., Pearson Education (2001).

6. S. L. Chuang, Physics of Photonic Devices, 2nd ed., New York: Wiley (2009).

7. Saleh and Teich, Fundamentals of Photonics, 2nd ed. Wiley Interscience (2007).

8. T.P. Pearsall, Photonics Essentials: An introduction with experiments, McGrawHill (2002).

9. E. Hecht, Optics, Pearson Education (2002).

10. R. Menzel, Photonics, Springer (2001).

11. N. Subramanyam, Brij Lal and M.N. Avadhanulu, Optics, S. Chand (2019).

11. R.S. Quimby, Photonics and LASERs-An Introduction, Wiley-Interscience (2006).

12. AmnonYariv, Optical Electronics, Holt Rine hart & Winston, Philadelphia (1991).

13. Ben G. Streetmann & Sanjay Banerjee, Solid State Electronic Devices, 5th Ed. (2000).

14. Bhattacharya P., Semiconductor Optoelectronic Devices, PHI, New Delhi1(1995).

COURSE OUTCOMES OF OPTOELECTRONICS AND PHOTONICS

Upon completion of this course, students would be able to:

CO-1. Understand the propagation of light in **guided media** and apply it.

CO-2. Understand Physics governing **LASER** and light matter interaction.

CO-3. Apply wave optics and diffraction theory to a range of problems.

CO-4. Apply the principles of **Optics and Photonics**.

CO-5. Understand the techniques of **Optical communication** and their **practical applications**.

PHY-MP-401: Thermal Physics Lab — Credit(s): 1

N.B.: Students are required to perform at least 6 experiments

List of Experiments

1. To determine **thermal conductivity** of a given material by **Lee's apparatus**.
2. To determine specific heat of the given material.
3. **To verify Stefan's law of radiations by using an incandescent lamp.**
4. **To study Adiabatic changes using Clement and de Sorme experiment.**
5. **To determine Callendar and Barne's constant flow method.**
6. **To determine the mechanical equivalent of heat (J) by Electrical method (Joule's Calorimeter)**
7. *To study conduction:* Composite wall experiment.
8. *To study convection:* Pool Boiling experiment.
9. *To study convection:* Experiment on heat transfer from tube-natural convection.
10. To study convection: Heat Pipe experiment.
11. *To study convection: Heat transfer through fin-natural convection.*
12. *To study convection: Heat transfer through tube/fin-forced convection.*
13. *Study of any experiment on Stefan's Law, on radiation determination of emissivity, etc.*

PHY-MP-404: Optoelectronics Lab — Credit(s): 1

N.B.: Students are required to perform at least 6 experiments from the following list:

1. To determine **Resolving power** of **Telescope**.
2. To determine the wavelength of prominent lines of Mercury by using plane **Diffraction Grating**.
3. To determine **Dispersive Power** of a Prism using Mercury light source and **Spectrometer**.

4. To determine the **Dispersive Power of a Plane Diffraction Grating**.

5. To determine **transmission coefficient** of a semi-transparent glass plate using **LB Photometer**.

6. To determine height of an unknown object using **Sextant**.

7. To measure **Numerical Aperture of an Optical Fiber**.

8. To determine the Coherent Length and Coherent Time of **LASER** using Semiconductor **LASER**.

9. To determine the profile of **He-Ne LASER** beam.

10. To determine the Wavelength and the Angular Spread of a He-Ne Laser.

PHY-MI-402: Basic Wave Mechanics and Optics (Physics Minor-IV) Credits-2

Unit-I: Superposition of Two Collinear Harmonic Oscillations
Linearity & Superposition Principle: (i) Oscillations having equal frequencies and (ii) Oscillations having different frequencies (Beats). **(4 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(2 Lectures)**

Waves Motion- General: 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. **(2 Lectures)**

Unit-II

Sound: Simple harmonic motion - forced vibrations and 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 Lectures)**

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **(2 Lectures)**

Interference: Interference: Division of amplitude and division of wavefront. 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. **(3 Lectures)**

Unit-III

Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. **(2 Lectures)**

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(5 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(3 Lectures)**

Suggested Readings:

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

2. B.K. Mathur, Principles of Optics, Gopal Printing (1995).

3. H.R. Gulati and D.R. Khanna, Fundamentals of Optics, R. Chand Publications (1991).

4. F.W. Sears, M.W. Zemansky and H.D. Young, University Physics (13/E), Addison-Wesley (1983).

Semester-V

PHY-MT-501: Mathematical Methods in Physics-II: Special Functions and Integral Transforms

Credit(s): 4

Unit-I
Beta and Gamma functions and its elementary properties, hypergeometric functions, Gauss hypergeometric functions and its elementary properties.

Unit-II
Bessel functions, Bessel differential equation and its solution, recurrence relation, generating functions, integral representation, and orthogonality of Bessel functions. Legendre polynomials and functions, solution of Legendre's differential equations, generating functions, Rodrigue's formula, orthogonality of Legendre polynomials, recurrence relations.

Unit-III
Laplace Transform, existence theorem, shifting theorems, Laplace transform of derivatives and integrals, inverse Laplace transform and their properties, convolution theorem, initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, 2^{nd} shifting theorem, applications of Laplace transform to solve IVP.

Unit-IV
Trigonometric Fourier series and its convergence, Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval`s identity, complex form of Fourier series, Fourier integrals, Fourier sine and cosine integrals, complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, convolution theorem, application of Fourier transforms to boundary value problems.

Unit-V
Z-Transforms: Z–transform and inverse Z-transform of elementary functions, shifting theorems, convolution theorem, initial and final value theorem, application of Z-transforms to solve difference equations.

Suggested Readings:

1. E. Kreyszing, Advanced Engineering Mathematics, John Wiley & Sons (1989).

2. R. K. Jain, S. R. K. Iyengar, Advanced Engineering Mathematics, Alpha Science International Ltd; 3rd Revised edition (2007).

3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd edition (2014).

1. G.B. Arfken, H J Weber, Mathematical Methods for Physicist, 4th ed. Academic Press (1995).

2. Mary Boas, Mathematical Methods in Physical Sciences, Wiley (2005).

3. P.M. Morse and H. Feshbach, Methods of Theoretical Physics (1953).

3. S. Hassani, Mathematical Physics: A Modern Introduction to its Foundations (1998).

4. Stephen J. Chapman, MATLAB Programming for Engineers, Thomson Press (2007).

5. Dr. B.S. Grewal, Higher Engineering Mathematics (2005).

6. Hassani, Sadri, Mathematical Methods of Physics and Related Fields2nd Ed. (2009).

7. Jon Mathews and Robert L. Walker, Mathematical Methods of Physics, University of Cambridge (1970).

8. Kreyszig, Erwin, Advance Engineering Mathematics, Loyola Marymount University, 10th Edition (2012).

PHY-MT-503: Modern Physics and Special Theory of Relativity **Credit(s): 4**

Unit-I

Particles and Waves: Inadequacies in Classical Physics. Blackbody Radiation: Quantum Theory of Light. Photoelectric Effect. Compton Effect. Franck-Hertz experiment. Wave Nature of Matter: De Broglie Hypothesis. Wave-Particle Duality. 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. Heisenberg's Uncertainty Principle (Uncertainty Relations involving Canonical Pair of Variables): Derivation from Wave Packets. γ-ray Microscope.

Unit-II

Time-independent and time-dependent Schrödinger Equation. Properties of Wave Function. Interpretation of Wave Function. Probability Density and Probability. Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Expectation Values. Wave Function of a Free Particle.

Unit-III

Applications of Schrödinger Wave Equation

Eigen Functions and Eigenvalues for a Particle in a One-Dimensional Box. Applications of Schrödinger's equation: (1) Finite Potential Step: Reflection and Transmission. Stationary Solutions. Probability Current. Attractive and Repulsive Potential Barriers. (2) Quantum Phenomenon of Tunneling: Tunnel Effect. Tunnel Diode (Qualitative Description). (3) Finite Potential Well (Square Well).

Unit-IV

Michelson-Morley Experiment and its Outcome.

Transformations: Galilean Transformations. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and Order of Events.

Proper Time. Length Contraction. Time Dilation. Relativistic Transformation of Velocity, Relativistic Addition of Velocities. Frequency and Wave Number.

Mass- energy Equivalence principle. Variation of Mass with Velocity. Relativistic relation between energy and momentum. Relativistic Doppler effect. Relativistic Kinematics.

Application of Special Relativity in Global Positioning System (GPS).

Unit-V

The Idea of Space-Time and Minkowski Space. Null-Cone representation. Metric Tensor.

Four Vector Formalism: Four Velocities, Four Momenta. Transformation of Energy and Momentum.

Bucherer's experiment. Segnac's experiment.

Equivalence Principle. Mach's Principle. Einstein's Box Experiments.

Suggested Books:

1. Arthur Beiser, Perspectives in Modern Physics, McGraw-Hill Book Company (1987).

2. J. B. Rajam, Atomic Physics (with foreword by Louis de Broglie), S. Chand & Co. (2007).

3. H.S. Mani and Mehta, Modern Physics, East-West Press Pvt. Ltd. (2016).

3. S. N. Ghoshal, Introduction to Nuclear Physics, S. Chand and Co. (2010).

4. David Bohm, Special Theory of Relativity, Routledge; 1st edition (1996).

Course Outcome (CO) of Mathematical Physics and Theory of Relativity

Upon completion of this course, students would be able to:

CO-1. Apply special mathematical function appropriately in solving problems in Physics.

CO-2. Understand the Dirac Delta, Fourier series and other distributions and be able to derive their various properties.

CO-3. Apply techniques of vector calculus, to the study of special functions of mathematical Physics.

CO-4. Understand effect of relative motion in the motion at very high speed.

CO-5. Understand effect of speed of light on variation in distance, time, length and mass.

PHY-MT-504: Solid State Physics — Credit(s): 4

Unit-I

Band Theory: Block theorem, Kronig Penny model, effective mass of electrons, Wigner-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

Unit-II

Semiconductors: law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory excitons, photoconductivity, photo-Luminescence. Points line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides. **Theory of Metals:** Fermi- Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi. Dirac statistics in the calculation of thermal conductivity and electrical conductivity, Widemann- Franz ratio, susceptibility, width of conduction band, Drude theory of light, absorption in metals.

Unit-III

Lattice Vibrations and Thermal Properties: Interrelations between elastic constants C11, C12 and C44 wave propagation and experimental determination of elastic constant of cubic crystal, vibrations of linear mono and diatomic lattices, Determination of phonon dispersion by inelastic scattering of neutrons.

Unit-IV

Magnetism: Larmor diamagnetism. Para-magnetism, Curie Langevin and Quantum theories. Susceptibility of rare earth and transition metals. Ferromagnetism: Domain theory, Veiss molecular field and exchange, spin waves: dispersion relation and its experimental determination by inelastic neutrons scattering, heat capacity. Nuclear Magnetic resonance: Conditions of resonance, Black equations. NMR-experiment and characteristics of an absorption line.

Unit-V

Superconductivity: (a) Experimental results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giver and AC and DC, Josephson tunnelling. (b) Cooper pairs and derivation of BCS Hamiltonian. Results of BCS theory. High T_C superconductors. Superconductivity at room temperature. Applications of Superconductors: SQUIDS. Cryotrons. Magnetic-Levitation. **Spin Waves and Plasma**. The idea of plasmons.

Suggested Readings

1. Adrianus J Dekker, Solid State Physics, Macmillan India Limited (2000)

2. C. Kittel, Introduction to Solid State Physics, John Wiley and Sons (2001).

3. N.W. Ashcroft, and N. D. Mermin , Solid State Physics, Harcourt Asia (P) Ltd. (2001).

4. M.A. Wahab, Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005).

5. A.R. Verma, and O.N. Srivastava, Crystallography for Solid State Physics, New Age International (2001).

6. S. O. Pillai, Solid State Physics, Wiley Eastern (1994).

7. S. O. Pillai, Problems in Solid State Physics (with Solutions), Tata McGraw Hill (1994).

Course Outcome (CO) of Advanced Solid State Physics

Upon completion of this course, students would be able to:

CO1. Understand different approaches to study band structures of solids and apply it in **Semiconductor Physics** and **Material Science**.

CO2. Understand properties of metals on the basis of the free electron gas models and exploit it.

CO3. Understand the essence of lattice vibrations and thermal properties and apply it in Material Science.

CO4. Understand magnetic phase transitions and magnetic structure properties and apply it to development of Material Science

CO5. Understand basics of (low temperature) superconductivity in type I and type II super conductors and explore its practical applications.

PHY-MP-503: Virtual Lab on Special Theory of Relativity and Quantum Mechanics

Credit(s): 02

*Students are required to perform any 3 Programming Exercises and 5 Virtual Runs

1. To write programme to simulate motion of a projectile.
2. To write programme on **length-contraction** formula and plot this expression.
3. To write programme on **time-dialation** formula and plot it geometrically.
4. To write programme on mass variation formula and plot this expression.
5. To write programme to evaluate scalar potential due to electric charge.
6. To compute and plot electric potential due to two point charges.
7. To plot electric field vector due to electric charge(s).
8. To write programme to evaluate Schrödinger's equation of motion.

In addition, students are advised to experience the following virtual exercises on Internet

V1-V11. Set of virtual experiments on 'Special Theory of Relativity' and 'Quantum Mechanics'

V1. **The Constancy of the Speed of Light and The Michelson-Morley Experiment**

https://galileoandeinstein.phys.virginia.edu/more_stuff/Applets/MichelsonMorley/michelsonmorley.html

https://demonstrations.wolfram.com/MichelsonMorleyExperiment/

https://lab.quantumflytrap.com/lab/michelson-morley?mode=waves

https://physicsmonster.org/content/simulation/simulation_relativity/index.html

V2. Time Dilation

https://galileoandeinstein.phys.virginia.edu/more_stuff/Applets/Lightclock/home.html

https://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_time_dilation

https://javalab.org/en/special_relativity_en/

V3. Length Contraction

https://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_length_contraction

https://javalab.org/en/special_relativity_2_en/

V4. Simultaneity

https://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_simultaneity

V5. Relative Speeds

https://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_speed_of_light

V6. Mass-Energy Equivalence

https://www.researchgate.net/publication/365733450_Application_of_Virtual_Reality_in_Learning_the_Concepts_of_Special_Relativity_and_Mass-Energy_Equivalence

V7. The "Speed" of Objects

https://physicsmonster.org/content/simulation/simulation_relativity/index.html#id_section_speed_of_light

V8. The Lorentz Contraction is Invisible

https://demonstrations.wolfram.com/LengthContractionVisualizationPoleAndBarn/

V9. Virtual experiment on Quantifying Uncertainty

https://www.mdpi.com/2673-8244/4/4/33#:~:text=To%20use%20a%20virtual%20experiment,i.e.%2C%20the%20parameter%20vector%20Z.

PHY-MI-502: Physics of Solids (Physics Minor-V) Credit(s): 2

Unit-I

Band Theory: Block theorem, Krönig Penny model, effective mass of electrons, Wigner-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method. **(6 Lectures)**

Semiconductors: law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory excitons, photoconductivity, photo-Luminescence. **(6 Lectures)**

Unit-II

Circuit Analysis: Kirchhoff's Laws, Mesh and Node Analysis of dc and ac Circuits, Duality in Networks. Network Theorems. Norton's Theorem. Thevenin's Theorem. Equivalent Star (T) and delta (π) Networks of a Given Network, Star to Delta and Delta to Star Conversion. Wheatstone Bridge and its Applications to Wein Bridge and Anderson Bridge. **(6 Lectures)**

Unit-III

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. (2) Zener Diode and Voltage Regulation. (3) Photo Diode, (4) Tunnel Diode, (5) LED (6) Varactor Diode. **(6 Lectures)**

Unit-IV

Magnetism: Larmor diamagnetism. Paramagnetism, Curie Langevin and Quantum theories. Susceptibility of rare earth and transition metals. Ferromagnetism: Domain theory, Weiss molecular field and exchange.

Superconductivity: (a) Experimental results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization. **(6 Lectures)**

***Suggested Readings*:**

1. Charles Kittel, Introduction to Solid State Physics, 7th Edition, John Wiley and Sons, Inc. ().

2. J. S. Blackmore, Solid State Physics, Cambridge University Press, Cambridge ().

3. N. W. Ascroft and N. D. Mermin, Solid State Physics, (Harcourt Asia, Singapore 2003).

4. S. O. Pillai, Solid State Physics, New Age Pub. (2018).

5. David J. Griffiths, Introduction to Electrodynamics, Benjamin Cummings, 1998 (Also, PHI).

6. A. J. Dekkar, Solid State Physics, Macmillan India Ltd. (2000).

7. A. P. Malvino, Electronic Principals, Glencoe (1993).

8. Allen Mottershead, Electronic Circuits and Devices, PHI (1997).

9. Adrianus J Dekker, Solid State Physics, Macmillan India Limited (2000)

10. A.R. Verma, and O.N. Srivastava, Crystallography for Solid State Physics, New Age International (2001).

PHY-MT-505: Field Visit/Student Project/Internship Credits-2

Semester VI

PHY-MT-601: Mathematical Methods in Physics-III: Partial Differential Equations

Credit(s): 4

Unit-I

Partial differential equation (PDE) of 1st order, method of characteristics, existence and uniqueness theorems, Cauchy problems, Lagrange's, compatible system of first order equations, solutions of nonlinear partial differential equations of 1^{st} order.

Unit-II

Special types of first order equations, Charpit's method-examples, Jacobi's method-example, Monge's method-examples.

Unit-III

Partial Differential Equations of Second and Higher Orders with constant coefficients. Classification of linear PDE of second order, equations with variable coefficients, reduction to canonical form.

Unit-IV

Methods of separation of variables, solutions of the one-dimensional wave equation, one-dimensional heat equation, Laplace equation two and three dimensional.

Unit-V

Nonlinear equations of the second-order, Green's functions and integral representations.

Suggested Readings:

1. T. Amarnath, An Elementary Course in Partial Differential Equations, (2nd edition), Narosa Publishing House (1997).
2. Phoolan Prasad, Renuka Ravindran, Partial Differential Equations, New Age International Publication, New Delhi (2009).
3. Ian N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Company, New York 1(957).
4. L.C. Evans, Partial Differential Equations, Graduate studies in Mathematics, Vol 19, AMS (1998).
5. F. John, Partial Differential Equations, 3rd ed. Narosa Publ. Co., New Delhi (1979).
6. M.D. Raisinghania, Ordinary and partial differential equations, S. Chand Publishing, New Delhi (2017).
7. R.K. Gupta, Partial Differential Equations, Krishna Prakashan, Meerut (2014).

PHY-MT-604: Atomic and Molecular Spectroscopy

Credit(s): 4

Unit-I

Determination of e/m of the Electron. Thermionic Emission. Isotopes and Isobars.

Introduction to Spectroscopy: X-rays: Ionizing Power, X-ray Diffraction, Bragg's Law. Bohr Atomic Model, Critical Potentials, X-rays-Spectra: Continuous and Characteristic X-rays, Moseley Law.

Unit-II

Atoms in Electric and 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 Bohr Magneton.

Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

Unit-III

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

Unit-IV

Structure of nuclei: Basic Properties of Nuclei: (1) Mass, (2) Radii, (3) Charge, (4) Angular Momentum, (5) Spin, (5) Magnetic Moment (μ), (6) Stability and (7) Binding Energy.

Radioactivity: Law of Radioactive Decay. Half-life, Theory of Successive Radioactive Transformations. Radioactive Series, Binding Energy, Mass Formula.

Unit-V

Molecular Spectra: Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra. Rotation- Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. Determination of Internuclear Distance.

Raman Effect: Quantum Theory of Raman Effect. Characteristics of Raman Lines. Stoke's and Anti-Stoke's Lines. Complimentary Character of Raman and infrared Spectra.

***Suggested Readings*:**

1. Arthur Beiser, Perspectives in Modern Physics, McGraw-Hill Book Company (1987).

2. J. B. Rajam, Atomic Physics (with foreword by Louis de Broglie), S. Chand & Co. (2007).

3. H.S. Mani and G.K. Mehta, Modern Physics, East-West Press Pvt. Ltd. (2016).

3. B.S. Brandsen and C.J. Joachain, Physics of Atoms and Molecules, Pearson (2001).

Course Outcome (CO) of Atomic and Molecular Physics

Upon completion of this course, students would be able to:

CO-1. Apply knowledge and techniques of Nuclear, Atomic and Molecular Phenomena.

CO-2. Use an understanding of models of Atomic and Molecular Physics.

CO-3. Design experiments and data acquisition techniques in Atomic and Molecular Physics.

CO-4. Analyze unknown radiations (from unknown source) and explore its mechanism of origin.

CO5. Analyze atomic and molecular spectra and to apply this understanding.

PHY-MT-603: Digital and Analog Circuits and Instrumentation Credit(s): 4

Unit-I

Number systems and Codes: Difference between Analog and Digital Circuits, Binary, Decimal, Hexadecimal and Octal number systems, Binary to Decimal, Decimal to Binary, Binary to Octal Conversions, arithmetic's (addition, subtraction and multiplication), Binary Addition, Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, Parity and Binary Coded Decimal (BCD) Codes **(10 Lectures)**

Unit-II

Logic Gates and Boolean algebra: AND, OR and NOT Gates (Realization with the help of Diodes and Transistors), NAND and NOR Gates as Universal Gates, XOR and XNOR Gates, De Morgan's Theorems, Basics of Boolean algebra and Boolean operators, Boolean Laws, Simplification of Logic Circuit using Boolean algebra, Minterms and Maxterms, Map Karnaugh. **(12 Lectures)**

Unit-III

Operational Amplifiers: Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain, CMRR, concept of Virtual ground, Applications of Op-Amps: (1) Inverting and Non-inverting Amplifiers (2) Adder (3) Subtractor (4) Differentiator (5) Integrator (6) Zero crossing detector.

(10 Lectures)

Unit-IV

Introduction to Digital Computer and Microprocessor

Digital Computers: General architecture and brief description of elements, Instruction set, addressing modes, Instructions format: Op-codes, mnemonics, programming system, higher level languages, Buses, CPU Timing and Signals; Control & status, Machine cycles, **Microprocessor:** Microprocessor and development system, Introduction of 8 and 16-bit Microprocessor, Pin diagram and its applications.

Timer IC: IC555 Pin diagram and its application as Astable and Monostable and Bistable Multi-vibrators

(15 Lectures)

Unit-V

Instrumentations: Digital Voltmeter (DVM); specifications, types, its advantages and disadvantages, Digital Multimeter (DMM); specifications, operations, advantages, disadvantages and applications, Cathode Ray Oscilloscope (CRO); basic principle of CRO and CRT, Block-diagram, CRO measurements, Applications and Digital Storage Oscilloscope (DSO); comparison of DSO and with analog oscilloscope and Applications **(10 Lectures)**

Suggested Books

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

2. S. Salivahanan & N.S. Kumar, Electronic devices & circuits, Tata Mc-Graw Hill (2012).
3. M.H. Rashid, Microelectronic Circuits, 2nd Edn., Cengage Learning (2011).
4. Helfrick & Cooper, Modern Electronic Instrumentation and Measurement Tech., PHI Learning (1990).
5. A.P. Malvino, D.P. Leach and Saha, Digital Principles and Applications, 7th Ed., Tata McGraw Hill (2011).
6. A.S. Sedra, K.C. Smith, A.N. Chandorkar, Microelectronic Circuits, Oxford University Press (2014).
7. A. Anand Kumar, Fundamentals of Digital Circuits, 2nd Edition, PHI Learning Pvt. Ltd (2009).
8. R.A. Gayakwad, OP-AMP & Linear Digital Circuits, PHI Learning Pvt. Ltd. (2000).
9. T. L. Floyd, Digital Fundamentals, Pearson International Publications, Ninth Edition (2000).
10. A.P. Malvino and D. P. Leach, Electronics Principles, McGraw Hill, Third Edition (2000).
11. R P Jain, Modern Digital Electronics, Tata McGraw-Hill Education (2003).
12. R. L. Tokheim, Digital Electronics: Principles and Applications, Tata McGraw-Hill Education (2013).
13. M. S. Tyagi, Introduction to Semiconductor Materials and Devices, John Wiley & Sons Inc. (1991).
14. Michael Shur, Introduction to Electronic Devices, John Wiley & Sons Inc. (2000).
15. R. T. Howe and C. G. Sodini, Microelectronics: An Integrated Approach, Prentice Hall Inc. (1997).
16. Allen Mottershead, Electronic Devices and Circuits, PHI Learning (1973).
17. Ben G. Streetman, Solid State Electronic Devices, PHI, 5th Ed. (2001).

Microprocessor & Microcontrollers

18. Krishna Kant, "Microprocessors and Microcontrollers", Prentice Hall of India (2013).
19. Yu-Cheng Liu, Glenn A.Gibson, "Microcomputer Systems: The 8086 / 8088 Family – Architecture, Programming and Design", Second Edition, Prentice Hall of India (2007).
20. Mohamed Ali Mazidi, J. Gillispie Mazidi, Rolin Mc Kinlay, The 8051 Microcontroller, Pearson (2012).
21. Doughlas V.Hall, ―Microprocessors and Interfacing, Programming and Hardware, TMH (2012).
22. A.K. Ray, K.M.Bhurchandi, "Advanced Microprocessors and Peripherals", Tata Mc GrawHill (2012).

PHY-MP-605: Analog Electronics Lab **Credit(s): 2**

N.B.: Students are required to perform at least 10 experiments from the following list:

1. To test a Diode and Transistor using (a) a Multimeter and (b) a CRO.
2. To measure (a) Voltage, (b) Frequency and (c) Phase Difference using a CRO.
3. To study **Diode/Zener Diode** characteristics.
4. To study **Transistor** characteristics.
5. To determine static resistance and dynamic resistance of p-n junction diode and plot the V-I characteristics

6. To plot the V-I characteristics of Zener diode and hence determine the dynamic resistance from the characteristics.
7. To observe output waveform of half wave rectifier with and without filter capacitor and measure DC voltage, DC current, ripple factor with and without filter capacitor.
8. To observe output waveform of full wave rectifier with and without filter capacitor and measure DC voltage, DC current, ripple factor with and without filter capacitor.
9. To observe waveform at the output of Bridge rectifier with and without filter capacitor and measure DC voltage, DC current, ripple factor with and without filter capacitor.
10. To design a full wave rectifier using discrete components on a breadboard and measure DC voltage, DC current, ripple factor with and without filter capacitor.
11. To obtain the input and output characteristics of common emitter transistor.
12. To obtain the input and output characteristics of common base transistor.
13. To draw DC load line of transistor working as a switch.
14. To obtain V-I characteristics of field effect transistor (FET).

PHY-MP-603: Digital Electronics Lab **Credit(s): 2**

N.B.: Students are required to perform at least 10 experiments from the following list:

1. To test: (i) AND, (ii) NAND, (iii) OR, (iv) NOR, (v) XOR Gates using digital circuit board/bread board.
2. To test and verify: (i) Product of Sum, and (ii) Sum of Product, using combinational circuit.
3. To test: Haff Adder and Full Adders using logic gates.
4. To study J-K Flip-Flop circuits.
5. To study counter circuits.
6. To study 'Shift Register' circuit.
7. To study encoder, decoder/de-multiplexer circuits using logic gates.
8. To study OP-AMP as inverting and non-inverting amplifier.
9. To study R-2R ladder network (D/A converter)
10. To solve Boolean expressions using Logic Gates.
11. To study analogue to digital and digital to analogue conversion.

Suggested Readings

1. P. R. Sasi Kumar, Practical Physics, PHI Pub. (2006).
2. K A. Navas, Electronics Lab Manual, PHI Ltd. (2015).
3. P. K. Palanisami, Physics Laboratory Manual, Scitech Publication (2002).

PHY-MI-602: Atomic and Molecular Physics (Physics Minor-VI) Credit(s): 2

Unit-I

Determination of e/m of the Electron. Thermionic Emission. Isotopes and Isobars. **(2 Lectures)**

Introduction to Spectroscopy: X-rays: Ionizing Power, X-ray Diffraction, Bragg's Law. Bohr Atomic Model, Critical Potentials, X-rays-Spectra: Continuous and Characteristic X-rays, Moseley Law.

(6 Lectures)

Unit-II

Atoms in Electric and 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 Bohr Magneton.

Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(12 Lectures)**

Unit-III

Structure of nuclei: Basic Properties of Nuclei: (1) Mass, (2) Radii, (3) Charge, (4) Angular Momentum, (5) Spin, (5) Magnetic Moment (μ), (6) Stability and (7) Binding Energy. **(2 Lectures)**

Radioactivity: Law of Radioactive Decay. Half-life, Theory of Successive Radioactive Transformations. Radioactive Series, Binding Energy, Mass Formula. **(4 Lectures)**

Molecular Spectra: Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra. Rotation- Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. **(4 Lectures)**

Suggested Books

1. Arthur Beiser: Concepts of Modern Physics, McGraw-Hill Book Company (1987).

2. J. B. Rajam (Foreword by Louis de Broglie), Atomic physics, S. Chand & Co. (2007).

3. Ghatak and Thyagarajan, Optoelectronics, Oxford University Press (2017).

4. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India, New Delhi (2001).

5. C. N. Banwell, Molecules Spectroscopy, McGraw Hill (1985).

6. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, 2nd Ed., Pearson (2008).

Semester VII

PHY-MT-701: Advanced Classical Mechanics Credit(s):4

Unit-I

Lagrangian and Hamiltonian Dynamics: Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.

Unit-II

Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle. The principle of least action.

Unit-III

Inertia Tensor: Inertial tensor. Moment and Product of Inertia. Rotational Dynamics. Pseudo forces. Coriolis forces. Similarity transformations.

Unit-IV

Canonical transformation, integral invariant of Poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton-Jacobi equation and its application.

Unit-V

Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

Suggested Readings

1. Herbert Goldstein, C. Poole, John Safko: Classical Mechanics, Pearson (2011).
2. L. D. Landau and E.M. Lifshitz: Mechanics, Pergamon Press (1969).
3. A. K. Raychoudhary, Classical Mechanics, Oxford University Press (1983).
4. N. C. Rana and P. S. Joag: Classical Mechanics, Tata McGraw Hill (2017).
5. Ronald L. Greene: Classical Mechanics with Maple, Springer (1995).
6. N. Mukunda and G. Sudarshan, Classical Dynamics: A Modern Perspective, HBA Books (1973).

Course Outcome (CO) of Atomic and Molecular Physics

Upon completion of this course, students would be able to:

CO-1. Have a deep understanding of Newtonian, Lagrangian and Hamiltonian Mechanics.

CO-2. Solve the non-Newtonian equations of different configurations using various techniques.

CO-3. Understand the niceties rotational motion and rigid body dynamics.

CO-4. Learn the idea of Lagrangian dynamics and its applications.

CO-5. Develop computational techniques based on "Advanced Classical Mechanics."

PHY-MT-704: Classical Electrodynamics–I   Credit(s): 4

(Electrodynamics in Vacuum or Free Space)

Unit-I: Electric Potential and Multipoles

Dipole radiations: Retarded potentials. Electric dipole and multi-pole radiations. Magnetic dipole radiations. Radiation from an arbitrary distribution of charges. Radiation from a point charge: Lienard-Wiechert potentials. The fields of a point charge in motion. Power radiated by a point charge.

Unit-II: Electromagnetism (Without Matter and Medium)

The idea of Four Potentials. Deriving Electro-magnetic field tensor using four potentials.

Relativistic electrodynamics using potential formulation: Field tensor and Electrodynamics in tensor notations. *Maxwell's equations in potential formulation*. Relativistic transformations of electro-magnetic fields

Unit-III: Gauge Transformations in Relativistic Electromagnetism

Lorentz' Force and the Electromagnetic Field. The origin of covariant derivative for Electrodynamics. Gauge transformations. Coulomb's gauge and Lorentz' gauge. Energy Momentum Tensor of the Electromagnetic Field.

Unit-IV

Wave propagation in radiation scenario. Frequency and wave-vector transformations. Reflection and refraction of electro-magnetic waves. Origin of refractive index. Dispersion.

Unit-V

Radiation reaction: The Abraham-Lorentz' formula. The physical origin of the radiation reaction.

Special radiative processes: Bremstrahlung. Synchrotron radiations. Cerenkov radiations. Fundamentals of magneto-hydrodynamics and plasma.

Suggested Readings

1. L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press (1984).

2. L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press (1984).

3. J. D. Jacksson: Classical Electro-dynamics; John Wiley (1998).

4. David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall/Pearson (2015).

5. Panofsky and Phillip: Classical Electricity and Magnetism, Dover Publication (2005).

Course Outcome (CO) of Classical Electrodynamics-I

Upon completion of this course, students would be able to:

CO1: Explain classical electrodynamics based on Maxwell's equations including its formulation in covariant form.

CO2: Solve the electromagnetic problems with the help of electrodynamic potentials and super-potentials, and make a detailed account for gauge transformations and their use

CO3: Formulate and solve electrodynamic problems in relativistic and covariant form in four-dimensional spacetime.

CO4: Calculate the electromagnetic radiation from localized charges which move arbitrarily in time and space, taking into account retardation effects.

CO5: Calculate the electromagnetic radiation from radiating systems, like oscillating electric and magnetic dipoles (aerials, localized charge and current distributions)

PHY-MT-703: Quantum Mechanics-I Credit(s):4

Unit-I

Linear spaces and Operators: Vector spaces, Linear independence, Bases, dimensionality and Isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete orthogonal set, Gramm-Schmidt orthogonalization procedure, Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Function space and Hilbert space. Complete orthonormal sets of functions.

Unit-II

Structure of Quantum Mechanics: Postulates of QM, Hilbert space; Hermitian and unitary operators; Orthonormality, completeness and closure. Dirac's *Bra* and *Ket* Representations. Matrix Representation and change of basis. Operators and observables, significance of eigenvector and eigenvalues, Commutation relation. Uncertainty principle for arbitrary Operators. Time-Evolution in Quantum Mechanics and Three Pictures. Fundamental Theorems of Quantum Mechanics.

Unit-III

Quantum Linear Harmonic Oscillator: Creation and annihilation operators. Occupation number. Quantization of creation and annihilation operators. Number operator. Coherent states and time-evolution of coherent states.

Unit-IV

Angular Momentum-I: Orbital angular momentum and Quantum Mechanics of rotations. Orbital angular momentum operators and their properties. Theory of Hydrogen-like atoms. Quantum Mechanics of rotations. Infinitesimal rotations. Euler angles. Three-dimensional oscillators. Rotation-vibration spectra of diatomic molecules.

Unit-V

Angular Momentum-II: Total angular momentum. Angular momentum operators: $\hat{J}_x, \hat{J}_y, \hat{J}_z, \hat{J}, \hat{J}^2$ and $\hat{J}_+$, and $\hat{J}_-$. Angular momentum eigen-values. Angular momentum matrices corresponding to spin half particles: Pauli's spinors and their properties.

Spin angular momentum. Stern-Gerlack experiment. Larmour's precession.

Total angular momentum and spin-orbit ($L-S$) coupling. Addition of angular momentum. Clebsch-Gordon coefficients. Selection rules.

***Suggested Readings*:**

1. Ashok Das and A.C. Melissions: Quantum Mechanics- A Modern Approach, Gordon and Breach Science Publishers.
2. Albert Messiah: Quantum Mechanics, Dover Publications
3. L. I. Schiff: Quantum Mechanics, Mc-Graw Hill.
4. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe: Quantum Mechanics, Wiley.
5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.
6. E. Merzbecher: Quantum Mechanics, John Wiley.

Course Outcome (CO) of Quantum Mechanics-I

Upon completion of this course, students would be able to:

CO-1: Understand the fundamentals of Quantum Mechanics specifically the 'Operator Mechanism in Quantum Mechanics'.

CO-2: Understand the 'Premise and Postulates of Quantum Mechanics'and make them understand Dirac's 'Bra and Ket representation'.

CO-3: Understand the theory of 'Quantum Linear Harmonic Oscillator' and 'The Idea of Creation and Annihilation Operators' and apply it in research in Advanced Physics.

CO-4: Understand- 'Theory of Angular Momentum in Quantum Mechanics' and apply it to 'Hydrogen-like Atom' and 'Spectroscopic Techniques'.

CO-5: Understand and apply the mathematical techniques of 'Total Angular Momentum' including 'selection rules' and 'Chlebsch-Gordon Coefficients'.

PHY-MT-705: Mathematical Methods in Physics-IV Credit(s): 04

(Special Mathematical Methods)

Unit-I: Special Mathematical Techniques

Dirac Delta Function: Definition. Representation and Properties of Dirac Delta Function.

Green's Function. Gamma and Beta functions. Sterling's formula.

Unit-II: Fourier Series

Periodic functions. Fourier series and series expansion of periodic functions. Orthonormal properties. Dirichlet's conditions. Asymptotic behaviour and Fourier series. Convergence. Summation of series. Rieman's Zeta function. Examples.

Unit-III: Matrices

Properties of Matrices. Orthogonal, Hermitian, Unitary, Identity, Nilpotent and Idempotent Matrices. Matrices as Operators. Diagonalization of Matrices. Eigen-Values and Eigen-Vectors of Matrices. Solving Linear equations by using Matrices.

Unit-IV: Groups and Symmetries

Groups and subgroups. Cosets. Quotient Groups. Cyclic groups. Normal subgroups. Groups defined on Matrices. Lie-groups. Special Orthogonal Groups $SO(n)$. Special Unitary Groups $SU(n)$. Specific cases of $SU(2)$ and $SU(3)$ Groups.

Unit-V: Vector Spaces

Vector Spaces. Dual spaces. Liner Dependence and Linear Independence. Inner Product of Vector Spaces. Linear Transformations. Important Inequalities: Cauchy-Schwarz inequality, Triangle inequality; and Gram determinant inequality. Group Morphisms.

Suggested References:

1. George Arfken, Mathematical Methods for Physicists, Academic Press (2012).
2. L. A. Pipes, Applied Mathematics for Engineers & Physicists, McGraw Hill (1970).
3. Merle C. Potter and Jack Goldberg: Mathematical Methods, Prentice Hall (1987).
4. Fredrick W. Byron and Robert W. Fuller: Mathematics of Classical and Quantum Physics, Dover Publications (1970).
5. V. Balakrishnan, Mathematical Physics, Ane Books Pvt Ltd. New Delhi (2018).
6. Tulsi Dass and S.K. Sharma: Mathematical Methods in Classical and Quantum Physics, Universities' Press (Orient Longman) (1998).

Course Outcome (CO)

CO-1: To learn to apply special mathematical function appropriately in solving problems in physics, understand the Dirac Delta and other distributions and be able to derive their various properties

CO-2: To learn to use Fourier transform to obtain the Fourier series of periodic functions in physics; and apply transform methods to solve elementary differential equations of interest in physics and engineering.

CO-3: To learn to apply of matrix diagonalization, matrix operations and matrix transformations.

CO-4: To be able to identify symmetries in Mathematics and Physics and associate appropriate group characteristics with them.

CO-5: To learn the properties of Linear Vector Spaces and their transformations.

PHY-MP-706: Advanced Physics Lab-1 Credit(s): 1

Students have to perform any 6 experiments

1. To verify *Hartmann's formula* using constant deviation spectrograph.
2. To study *ESR* and determine *g*-factor for a given spectrum.
3. To find e/m of electron using *Zeeman effect*.
4. To determine *internal friction* at the *grain boundaries of solids* using *torsional pendulum*.
5. To study a *driven mechanical oscillator*.
6. To study *coupled pendulums*.
7. To study the *dynamics of a lattice* using electrical analog.
8. To study the variation of rigidity of a given specimen as a function of the temperature.

11. Verification of *Bragg's law* using microwaves.

Suggested Readings:

1. P. R. Sasi Kumar, Practical Physics (2006) PHI Pub.
2. K. Ventat Raman, R. Raja and M. Sunder Rajan, Experimental Physics (2014) Scintech Publications.
3. S. K. Ghosh, A Text Book of Practical Physics (2008) New Central Book Agency.
4. D. Chattopadhyay and P. Rakshit, An Advance Course in Practical Physics (2011) New Central Book Agency.

PHY-MP-707: Advanced Physics Lab-2 Credit(s): 1

Students are required to perform any 6 experiments from the following:

1. To determine velocity of sound in air using CRO.
2. To determine velocity of sound in liquids using Ultrasonic interferometer.
3. To determine velocity of sound in solids by pulse-echo method.
4. To study Faraday effect and Verdent’s constant of a given material
5. To study wavelength of an unknown light source using Compact Disk.
6. To determine the distance between grooves of a Compact Disk.
7. To study electro-optic modulation.

8. To study magnet-optic modulation.

9. To determine the particle size of a given (unknown) material.

10. To study Raman scattering using LASER source.

Suggested Readings

1. P. R. Sasi Kumar, Practical Physics, PHI Pub. (2006).
2. K. V. Raman, R. Raja and M. S. Rajan, Experimental Physics, Scintech Pub. (2014).
3. S. K. Ghosh, A Text Book of Practical Physics, New Central Book Agency (2008).
4. D. Chattopadhyay & P. Rakshit, Advance Course in Practical Physics, New Central Book Agency (2011).

PHY-MI-702: Introductory Numerical Techniques in Physics Credit(s): 2

Unit–I:

Introduction - Representation of integers and real numbers; Accuracy, range; error propagation. Solutions of algebraic and transcendental equations - Bisection, Newton-Raphson Method**.** Solution of System of Equations using Iteration Method- Gauss elimination method, Gauss Jordan method, Gauss-Seidel, Relaxation Method.

Unit–II:

Interpolation with equal intervals-Newton's Backward and Forward formula. Central Difference Interpolation: gauss's Forward and backward formula**.** Interpolation with unequal intervals – Newton divided difference.

Unit–III:

Numerical Differentiation and Integration– Maxima and minima**,** Trapezoidal formula, Simpson's 1/3 and 3/8 formula. Romberg Method. Numerical Solutions of Ordinary Differential Equations- Euler Method, Runge-Kutta Formula – First, Second, Third and Fourth Order Method.

Suggested Readings

1. Dr. B.S. Grewal, "Numerical methods in *Engineering and Sciences*", Khanna Pub., New Delhi (2014).
2. P. Kandsamy "*A Text book on Engineering Mathematics*", 3rd Edition, S. Chand & Company Ltd. (2009).
3. S. S. Sastry, "*Numerical Methods*", 4th Edition , Prentice Hall of India (2008).
4. N.P. Bali et. al, "*A Text book on Engineering Mathematics*", Laxmi pub.(p) Ltd. (2001).
5. Erwin Kreyszig, "*Advanced Engineering Mathematics*", John Wiley Publications (1999).
6. R.K. Jain & S. R. K. Iyengar, "*Numerical Methods*", New Age International (P) Ltd. (2008).

Semester VIII

PHY-MT-801: Statistical Thermodynamics **Credit(s): 4**

Unit-I

Elementary Probability Theory: Preliminary concepts, Random walk problem, Binomial distribution, mean values, standard deviation, various moments, Gaussian distribution, Poisson distribution, mean values. Probability density, probability for continuous variables. **Extensive and Intensive Variables**: laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material. The laws of thermodynamics and their consequences.

Unit-II

Statistical Description of System of Particles: State of a system, microstates, ensemble, basic postulates, behavior of density of states, density of state for ideal gas in classical limit, thermal and mechanical interactions, quasi-static process. Statistical thermodynamics: Irreversibility and attainment of equilibrium, Reversible and irreversible processes. Thermal interaction between macroscopic systems, approach to thermal equilibrium, dependence of density of states on external parameters, Statistical calculation of thermodynamic variables.

Unit-III

Canonical and Grand Canonical Ensembles: Concept of statistical distribution, phase space, density of states, Liouville's theorem, systems and ensemble, entropy in statistical mechanics Connection between thermodynamic and statistical quantities micro canonical ensemble, equation of state, specific heat and entropy of a perfect gas, using micro canonical ensemble. Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of mean values, energy fluctuation in a gas, grand Canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuations.

Unit-IV

Partition Functions and Statistics: Partition functions, Properties, partition function for an ideal gas & calculation of thermodynamic quantities, Gibbs Paradox, validity of classical approximation, translational, rotational & vibrational contributions to the partition function of an ideal diatomic gas. Specific heat of a diatomic gas, ortho & para-Hydrogen. **Maxwell-Boltzmann Gas Velocity and Speed Distribution**: Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transition; phase equilibrium.

Unit-V

Formulation of Quantum Statistics: Density Matrix, ensembles in quantum statistical mechanics, simple applications of density matrix. Theory of simple gases: Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac gases. Statistics of occupation numbers, Evaluation of partition functions, Ideal gases in the classical limit.
Ideal Bose System: Thermodynamic behavior of an Ideal Bose gas, **Bose-Einstein condensation**. Thermodynamics of Black body radiation, Stefan-Boltzmann law, Wien's displacement law. Specific heat of solids (Einstein and Debye models).
Ideal Fermi System: Thermodynamic behavior of an ideal Fermi gas, degenerate Fermi gas, Fermi energy and mean energy, Fermi temperature, Fermi velocity of a particle of a degenerate gas. **Black Holes, White Dwarfs and Chandrashekhar Limit.**

Suggested Readings

1. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw Hill (1927).

2. K. Huang, Statistical Mechanics, John Wiley & Sons (1987).

3. L. D. Landau and E. M. Lifshitz, Statistical Physics, Butterworth-Heinemann (1996).

4. Richard P. Feynman, Lectures on Statistical Mechanics, CRC Press (1998).

Course Outcome (CO) of Statistical Thermodynamics

Upon completion of this course, students would be able to:

CO1. Describe and apply the concepts of microstate and macro-state of a model system.

CO2. Describe and apply the concepts and roles of entropy and free energy from the view point of statistical mechanics

CO3. Describe and apply the Boltzmann distribution and the role of the partition function

CO4. Apply the machinery of statistical mechanics to the calculation of macroscopic properties resulting from microscopic models of magnetic and crystalline systems

CO5. Describe and apply Fermi-Dirac and Bose-Einstein distributions; state whereever they are applicable; and appreciate how they differ and show when they reduce to the Boltzmann distribution.

PHY-MT-804: Mathematical Methods in Physics-V: Special Mathematical Techniques

(Elective) **Credit(s): 4**

Unit-I: Orthogonal Curvilinear Coordinates

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems and their Physical Perspective. Scale factors and transformations. Area and volume elements.

Unit-II: Vector Calculus

Vector Calculus: Vector Differentiation. Scalar and Vector Fields. Ordinary and Partial Derivative of a Vector *wrt* coordinates. Space Curves. Unit Tangent Vector and Unit Normal Vector. Directional Derivatives and Normal Derivative. Gradient of a Scalar Field and its Geometrical Interpretation. Divergence and Curl of a Vector Fields. Laplacian Operators. Vector Identities. Idea of Jacobian. Vector Integration**:** Ordinary Integral of Vectors. Line, Surface and Volume Integrals. Flux of a Vector Field. Gauss' Divergence Theorem, Green's Theorem and Stokes Theorem.

Unit-III

Introduction to Tensors. The idea of Covariant, Contravariant and Mixed tensors of rank 1, 2 and 3. Raising and Lowering tensors. Transformations. Levi-Civita tensor. Algebra of tensors. Calculus of tensors. Christoffel symbols of First and Second kind. Covariant differentiation of tensors. The idea of Geodesics.

Unit-IV: Complex Variables

Complex Variables: Limits and continuity. Analytical functions. Cauchy- Riemannn conditions. Differentiation. Cauchy Integral theorem. Cauchy integral formula. Derivatives of analytical functions. Liouville's theorem.

Complex Variables: Functions of complex variable. Conformal mappings and representations.

Unit-V: Complex Variables

Power series: Taylor's series and McLaurin's series. Singularities. Idea of Residues. Complex Integration.

The idea of Analytic continuation. **Saddle Point Function**.

Suggested Books:

1. George Arfken, Mathematical Methods for Physicists, Academic Press (2012).
2. L. A. Pipes, Applied Mathematics for Engineers & Physicists, McGraw Hill (1970).
3. Merle C. Potter and Jack Goldberg: Mathematical Methods, Prentice Hall (1987).
4. Fredrick W. Byron and Robert W. Fuller: Mathematics of Classical and Quantum Physics, Dover Publications (1970).
5. V. Balakrishnan, Mathematical Physics, Ane Books Pvt Ltd. New Delhi (2018).
6. Tulsi Dass and S.K. Sharma: Mathematical Methods in Classical and Quantum Physics, Universities' Press (Orient Longman) (1998).

Course Outcomes (CO)

CO-1: To learn the idea of curvilinear coordinates and to be able to make transformations from one-co-ordinate system to another proficiently.

CO-2: To understand the idea of vector and scalar fields. To learn to apply techniques of gradient of scalar, and divergence and curl of vector fields in Physics wherever need be.

CO-3: To learn to use of Fourier and Laplace transformations to solve differential equations, apply techniques of complex variables, to the study of special functions of mathematical physics.

CO-4: To learn to solve partial differential equations with appropriate initial or boundary conditions; and understand Group theory, special unitary groups.

CO-5: To learn to solve mathematical problems arising in physics by a variety of mathematical techniques.

PHY-MT-803: Advanced Numerical Techniques in Physics (Elective) Credit(s): 4

Unit–I:

Introduction - Representation of integers and real numbers; Accuracy, range, overflow and underflow of number representation; error propagation and instability. Introduction: Solutions of algebraic and transcendental equations - Bisection, Regula Falsi, Secant method, Newton-Raphson Method

Unit–II:

Solution of System of Equations using Iteration Method - Cramers's rule, Matrix inversion method, Gauss elimination method, Gauss Jordan method. Iterative method of Solution -Jacobi method, Gauss-Seidel, Relaxation Method.

Unit–III:

Interpolation with equal intervals- Newton's Backward and Forward formula. Central Difference Interpolation: gauss's Forward and backward formula, Sterling Formula, Bessel Formula

Interpolation with unequal intervals – Lagrange's Formula, Newton divided difference.

Unit–IV:

Numerical Differentiation and Integration–Maxima and minima**,** Newton-Cotes quadrature formula, Trapezoidal formula, Simpson's 1/3 and 3/8 formula, weddles's rule. Romberg Method.

Unit–V:

Numerical Solutions of Ordinary Differential Equations- Picard's Method, Taylor Series Method, Euler Method, Modified Euler Method, Runge-Kutta Formula – First, Second , Third And Fourth Order Method. Milne's Method.

Suggested Readings

1. B.S. Grewal, "Numerical methods in *Engineering and Sciences*", 43rd Edition, Khanna Publishers, New Delhi (2014).
2. P. Kandasamy "*A Text book on Engineering Mathematics*", 3rd Edition, S. Chand & Company Ltd. (2009).
3. S. S. Sastry, "*Numerical Methods*", 4th Edition , Prentice Hall of India (2008).
4. N.P. Bali *et. al*, "*A Text book on Engineering Mathematics*", Laxmi pub.(p) Ltd (2001).
5. Erwin Kreyszig, "*Advanced Engineering Mathematics*", John Wiley Publications (1999).
6. R.K. Jain & S. R. K. Iyengar, "*Numerical Methods*", New Age International (P) Ltd. (2008).
7. E. Balagurusamy, Numerical Methods, Tata McGraw Hill (2017).

PHY-MT-805: Instrumentation Techniques (Elective) Credit(s): 4

Unit-I: Classification of Instruments

Absolute and Secondary instruments, indicating instruments, control, balancing and damping, construction details, characteristics, errors in measurement.

Wattmeters: Induction type, single phase and three phase wattmeter's, compensations.
Energy meters: AC Induction type single phase and three phase energy meter compensation, creep, error, testing.
Frequency meters: Vibrating reed type, electrical resonance type
Transducer: Strain Gauges, Thermistors, Thermocouples. Linear Variable Differential Transformer (LVDT) Capacitive Transducers, Peizo-Electric transducers. Optical Transducer, Torque meters, inductive torque transducers, electric tachometers, photo electric tachometers.

Unit-II
Electronic Instruments
CRO: Block Diagram, sweep generation, vertial amplifiers, use of CRO in measurement of frequency, phase, Amplitude and rise time of a pulse.
Digital Multimeter: Block diagram, principle of operation, Accuracy of measurement
Electronic Voltmeter:
Transistor Voltmeter, Block diagram, principle of operation, accuracy of measurement: metering amplifier.

Unit-III

Power Semiconductor Devices
Power Diodes: Types, characteristics
Thyristors: SCR, Static V-I characteristics of SCR, two transistor analogy of SCR, dynamic characteristics of SCR, Gate characteristics of SCR, Thyristor ratings, DIAC, TRIAC, GRO, UJT.
Power Transistors: Power BJT, Power MOSFETS, IGBT.
Triggering Circuits: R- Triggering, R-C Triggering, UJT triggering, Design of UJT triggering circuit, Cosine law triggering, triggering circuit using pulse train.
Thyristor commutation circuits: Class-A, Class-B, Class-C, Class-D, Class-E, Class-F commutation circuits.

Unit-IV
Sensors and Transducers

Basic concepts and Classification: Introduction, System Configuration, Problem Analysis, Basic Characteristics of Measuring Devices, Calibration
Transducer classification: Introduction, Electrical Transducer, Classification, Basic Requirements of a Transducer. Introduction, Principles of Transduction, Digital Transducers, Level Measurements
Strain Measurement: Introduction, Factors affecting Strain Measurements, Types of Strain Gauges, Theory of Operation of Resistance Strain Gauges, Types of Electrical Strain Gauges, Materials for Strain Gauges, Gauging Techniques and Other Factors, Strain Gauge Circuits, Temperature Compensation, Applications.

Unit-V
Pressure Transducer: Introduction, Diaphragms, Other Elastic Elements, Transduction Methods, Force-Balance Transducer, Solid State Devices, Thin Film Pressure Transducers, Piezoelectric Pressure Transducer, Vibrating Element Pressure Sensors, Pressure Multiplexer, Pressure Calibration
Temperature Transducer: Introduction, Temperature Scales, Mechanical Temperature Sensors, Resistance- Type Temperature Sensors, Platinum Resistance Thermometer, Thermistors. Thermocouples, Solid-State Sensors, Quartz
Thermometer, Temperature Measurement by Radiation Methods, Optical Pyrometer, Calibration of Thermometers.
Force and Torque transducer: Introduction, Force-Measuring Sensor- Load Cell, Effect of Temperature Variations, Dynamic Response of Elastic Transducers, Digital Force Transducers, Force-Balance Device, Hydraulic Load Cell, Electronic Weighing System, Torque Measurement.
Vibration Transducers: Introduction, Characteristic of Vibration, Analysis of Vibration-Sensing Devices, Vibration- Sensing Devices, Signal Conditioners, Shock Measurements, System Characteristics, Vibration Exciters, Calibration.

***Suggested Readings*:**

1. D.V.S. Murty, Instruments and Transducers, PHI (2022).

2. M.H. Rashid, Power Electronics, Pearson Publication (2017).

3. J. Jacob, Power Electronics Principles and Applications, Cengage Learning (2001).

4. V.R. Murthy, Power Electronics, Oxford Publication (2005).

5. A.K. Sawhney, A Course in Elec. & Electronic Measurement and Instrumentation, Dhanpat Rai & Sons, New Delhi (1995).

6. W.O. Cooper, Electronic Instrumentation and measurement techniques, Prentice Hall of India Limited, New Delhi (1992).

7. Larry Jones & A foster Chin, Electronic measurement and Instrumentation systems, Pearson (1990).

8. Golding E.W., Electronic Measuring Instruments, Wheeler & Company, Calcutta (1993).

9. C.S. Rangan, G.R. Sarma, V.S.V. Mani, Instrumentation Devices and Systems, Tata McGraw Hill publishers (2017).

(Microprocessor & Microcontrollers)

10. Krishna Kant, "Microprocessors and Microcontrollers", Prentice Hall of India (2013).

11. Yu-Cheng Liu, Glenn A. Gibson, "Microcomputer Systems: The 8086 / 8088 Family – Architecture, Programming and Design", Second Edition, Prentice Hall of India (2007).

12. Mohamed Ali Mazidi, J. Gillispie Mazidi, Rolin Mc Kinlay, The 8051 Microcontroller, Pearson (2012).

13. Doughlas V. Hall, ―Microprocessors and Interfacing, Programming and Hardware, TMH (2012).

14. A.K. Ray, K.M. Bhurchandi, "Advanced Microprocessors and Peripherals" 3rd edition, Tata Mc Graw Hill (2012).

(Experimental Techniques)

15. J. Yarwood, High vacuum techniques, Chapman & Hall (1967).

16. A. Roth, Vacuum Technology, North-Holland Publishing Company, Amsterdam (1982).

17. G.K. White, Experimental Techniques in Low Temperature Physics, Oxford (1968).

18. L.C. Jackson, Low temperature physics, Methuen, London (1950).

19. O.V .Lounasmas, Experimental Principles & Methods Below 1 K, Academic press, New York (1974).

20. R.E. Smallman and K.H.G. Ashbee, Modern Metallography, Pergamon Press, Oxford (1966)

21. D.K. Bowen and C.R. Hall, Microscopy of materials, (The MacMillan Press Ltd., London (1975).

22. L.E. Murr, Electron Optical Applications in Materials Science, McGraw Hill, New York, (1970).

23. B. Welz, Atomic Absorption Spectroscopy, Verlag Chemie, New York (1976).

24. R.J. Reynolds, K. Aldous and K.C. Thompson, Atomic absorption spectroscopy, Charles Griffin and Company Ltd., London (1970).

25. C. Vandecasteele and C.B. Block, Modern Methods for Trace Element Determination (John Wiley & Sons, New York (1993).

26. D.A. Skoog and J.J. Leary, Principles of Instrumental Analysis, Saunders College publishing (1992).

27. Straughan & Walker, Spectroscopy, Vol. 1, Chapman & Hall, London (1976).

PHY-MP-807: Great Experiments in Physics — Credits: 2

NB: Students are required to perform any 10 experiments

1. *Frank-Hertz'* experiment: To determine Planck's constant.

2. *Millican's Oil Drop experiment*: To determine e/m of electron.

3. *Thomson's experiment*: To determine e/m of electron.

4. *Bragg's experiment*: To study diffraction of X-Rays in solids.

5. *Compton Effect*: To study of Compton scattering of γ- rays.

6. *Faraday's experiment*: To study Electromagnetic Induction and Laws of Electrolysis.

7. *Joule's experiment*: To determine of mechanical equivalent of heat.

8. *Davisson Germer's* experiment: To study diffraction of X-Ray in solids.

9. *Stern-Gerlach experiment*: To study of spin of (electrons) fundamental particles.

10. Michelson's Interferometer: To perform experiment of interference with Michelson's Interferometer.

11. *Hall effect*: To study *Hall effect* and determine *Hall coefficient*.

12. Thomson's method: e/m To determine e/m of electron.

Suggested Readings

1. Morris H. Shamos, Great Experiments in Physics, Dover Publications Inc. (New York 1959).

2. Adrian C. Melissinos and Jim Napolitano, Experiments in Modern Physics, Academic Press (2003).

PHY-MI-802: Nuclear and Particle Physics Overview — Credit(s): 2

Unit-I

General Properties of Nuclei: Introduction. Parity and isospin of nuclei. Charge Form Factor. Electric and Magnetic multi-pole (dipole and quadrupole) moments. Deuteron: Ground state and excited states. Exchange nature of Nuclear Forces.

Unit-II

Nuclear Models: Fermi Gas model. Magic Numbers and Shell Model. Unified Model. Nuclear Fission and Nuclear Fusion. Beta and Gamma Emission. Fermi Theory of Beta Decay.
Detectors and Accelerators: Introduction to Nuclear Detectors: Proportional Counters. GM Counters. Scintillation Counters.
Introduction to Particle Accelerators: Palletron. Lenear Accelerators. Cyclotrons. Large Particle Colliders.

Unit-III

Fundamental Particles: Relativistic energy and momentum of particles. Scalar particles. Mesons.
Particle Classification: Fermions and Bosons. Fundamental and Composite Particles.
Types of Particle Interactions (Introduction only): Quantum Electrodynamics (QED). Strong Interactions or Quantum Chromodynamics (QCD). Weak Interactions.
Symmetries and Quantum Numbers: Parity (P), Time-reversal (T), Charge Conjugation (C), and CP and CPT operations and symmetries. CPT Theorem.

***Suggested Readings*:**

1. Arthur Beiser, Perspectives in Modern Physics, McGraw-Hill Book Company (1987).

2. J. B. Rajam, Atomic Physics (with foreword by Louis de Broglie), S. Chand & Co. (2007).

3. H.S. Mani and Mehta, Modern Physics, East-West Press Pvt. Ltd. (2016).

3. S. N. Ghoshal, Introduction to Nuclear Physics, S. Chand and Co. (2010).

4. David Griffiths: Introduction to Elementary Particles, Wiley (2008).

4. Review of Particle Physics, (Particle Data Group, 2020); https://pdg.lbl.gov/2020/

5. W.E. Burcham and M. Jobes, Nuclear and Particle Physics, Addison Wesley, Longman, England (1995).

6. B.L. Cohen, Concept of Nuclear Physics, Tata McGraw-Hill (2005)

7. Iriving Kaplan, Nuclear Physics, Narosa, Madras (1989).

8. Donald H.Perkins, Introduction to High Energy Physics, Addison Wesley, Massachusetts (1982).

9. Robley D. Evans, The Atomic Nucleus, McGraw-Hill, New York (1955).

10. M.P. Khanna, Introduction to Particle Physics, Prentice Hall, India (1999).

Course Outcome (CO) of Atomic and Molecular Physics

Upon completion of this course, students would be able to:

CO-1. Apply knowledge and techniques of Nuclear, Atomic and Molecular Phenomena.

CO-2. Use an understanding of models of Atomic and Molecular Physics.

CO-3. Design experiments and data acquisition techniques in Atomic and Molecular Physics.

CO-4. Analyze unknown radiations (from unknown source) and explore its mechanism of origin.

CO5. Analyze atomic and molecular spectra and to apply this understanding

PHY-MT-806: Dissertation/Research Project **Credit(s): 12**

PHY-MT-806	**Dissertation (Optional)** **Components of 12 Credits: Project Work+Dissertation+*Viva-Voce***	**12**