Faculty of Sciences

Course Structure and Syllabi

B. Sc. (Physics Major)

2022

(As Per New Education Policy 2020)

Department of Physics

Indira Gandhi National Tribal University

Amarkantak 484887

Proposed Course Structure of the academic program with multiple entry and exit and credit distribution as per UGC guideline (New Education Policy)

Semester	Disciplinary Major 40-56	Minors 24		Multidisciplinary (Major) 40-56	Vocational 12	Total Credits	Entry/Exit options
		Minor 1	Minor 2				
1st	4+2	2	2	4+2	2+2	20	Entry
2nd	4+2	2	2	4+2	2+2	**40**	**Certificate** (Exit)
3rd	4+2	2	2	4+2	2+2	60	Entry
4th	4+2	2	2	4+2	2+2	**80**	**Diploma** (Exit)
5th#	4+2 without internship or 4+2+4 with internship	2	2	4+2 without internship or 4+2+4 with internship	-	100	Entry
6th#	4 + 4 + 2+2 Or 4	2	2	4 + 4 + 2+2 Or 4	-	**120**	**Bachelor Degree*** (Exit)
7th#	4 + 4 + 2+2+2 Or 4 +2			4 + 4 + 2+2+2 Or 4 +2	-	140	Entry
8th	Research 20					**160**	**Bachelor Hons/Res**. Degree** (Exit)
9th	20 (4+4+4+4+2+2)					140*/180**	Entry
10th	20 (4+4+4+4+2+2)					160*/200**	**One Year Master Degree** or PG Diploma*** (Exit)
11th	20 (4+4+4+4+2+2)					180*	Entry
12th	Research 20					200*	**Two Years Master Degree**
	Doctoral Degree					Minimum Credits as per Course Work and thesis with Publications	

The four-year undergraduate program should comprise, 1. Disciplinary Majors (40-56 credits), 2. Multi-/Inter-disciplinary Majors (40-56), 3. Disciplinary/Inter-disciplinary Minors (20-28), 4. Vocational (12-18), and Field Visits/Internships/Apprenticeship/Community engagement & service (24-32 credits). #Students will choose any one option for disciplinary/inter-disciplinary majors but not the same option for both.

Physics for B.Sc. (Major and Minor) Programme

Course Code	Course/Paper	Credits
	Semester-I	
PHYDMT-101	**Mechanics, Waves and Oscillations**	**4**
PHYDMP-107	**Mechanics Lab**	**2**
PHYDMI-102	**Minor-I:** Mechanics	**2**
PHYIDMT-103	**Mechanics, Waves and Oscillations**	**4**
PHYIDMP-108	**Mechanics Lab**	**2**
PHYIDMI-104	**Minor-I:** Mechanics	**2**
PHYVOT-105	**Computational Physics-1 (Vocational-1)**	**2**
PHYVOP-106	**Computational Physics-1 (Voc. Lab-1)**	**2**
	Total Credits	**12**
	Semester-II	
PHYDMT-201	**Thermodynamics**	**4**
PHYDMP-207	**Thermal Physics Lab**	**2**
PHYDMI-202	**Minor-II: Electricity and Magnetism**	**2**
PHYIDMT-203	**Thermodynamics**	**4**
PHYIDMP-208	**Thermal Physics Lab**	**2**
PHYIDMI-204	**Minor-II:** Electricity and Magnetism	**2**
PHYVOT-205	**Computational Physics-2 (Vocational-2)**	**2**
PHYVOP-206	**Computational Physics-2 (Voc. Lab-2)**	**2**
	Total Credits	**12**
	Semester-III	
PHYDMT-301	**Electricity and Magnetism**	**4**

PHYDMP-307	**Electricity and Magnetism Lab**	2
PHYDMI-302	**Minor-III: Thermodynamics**	2
PHYIDMT-303	**Electricity and Magnetism**	4
PHYIDMP-308	**Electricity and Magnetism Lab**	2
PHYIDMI-304	**Minor-III:** Thermodynamics	2
PHYVOT-305	**Optoelectronics and Photonics (Vocational-3)**	2
PHYVOP-306	**Optoelectronics and Photonics (Voc. Lab-3)**	2
	Total Credits	12
	Semester-IV	
PHYDMT-401	**Solid State Electronics**	4
PHYDMP-407	**Electronics Lab**	2
PHYDMI-402	**Minor-IV:** Wave Optics and Photonics	2
PHYIDMT-403	**Solid State Electronics**	4
PHYIDMP-408	**Electronics Lab**	2
PHYIDMI-404	**Minor-IV:** Wave Optics and Photonics	2
PHYVOT-405	**Energy Studies: Solar and Alternative Sources of Energy (Vocational-4)**	2
PHYVOP-406	**Energy Studies4Lab (Voc. Lab-4)**	2
	Total Credits	12
	Semester-V	
PHYDMT-501	**Mathematical Physics and Special Theory of Relativity**	4
PHYDMP-507	**Virtual Lab on Special Relativity**	2
PHYDMI-502	**Minor-V:** Solid State Physics and Electronics	2
PHYIDMT-503	**Mathematical Physics and Special Theory of Relativity**	4
PHYIDMP-508	**Virtual Lab on Special Relativity**	2

PHYIDMI-504	**Minor-V:** Solid State Physics and Electronics	**2**
PHYFV/I-505	**Field Visit/Internship**	**4**
PHYFV/I-506	**Field Visit/Internship**	**2**
	Total Credits	**20**
	Semester-VI	
PHYDMT-601	**Atomic and Molecular Physics**	**4**
PHYDMP-606	**Modern Physics Lab**	**2**
PHYDMI-602	**Minor-VI:** Atomic and Molecular Physics	**2**
PHYIDMT-604	**Atomic and Molecular Physics**	**4**
PHYDMT-603	**Digital, Analog Circuits and Instrumentation Physics**	**4**
PHYIDMI-605	**Minor-VI:** Atomic and Molecular Physics	**2**
PHYDMP-607	**Internship**	**2**
	Total Credits	**20**
	Semester-VII	
PHYDMT-701	**Advanced Classical Mechanics**	**4**
PHYDMT-702	**Quantum Mechanics-I**	**4**
PHYDMT-703	**Classical Electrodynamics-I**	**4**
PHYDMT-704	**Statistical Thermodynamics**	**4**
PHYDMP-705	**Advanced Physics Lab-1**	**4**
PHYDMP-705	**Advanced Physics Lab-2**	**4**
	Total Credits	**20**
	Semester-VIII	
PHYD-801	Dissertation (Four Components carrying 20 Credits)	**20**

PHYD-801A	Lab Work/Field Work/Field Survey/Industrial Visit/Institutional Visit/Data Collection/Internship etc.	**4**
PHYD-801B	Pre-Submission Presentation	**4**
PHYD-801C	Report Writing/Write-up/Dissertation Report	**8**
PHYD-801D	Viva-Voce	**4**
	Semester IX	
PHYDMT-901	**Nuclear Physics**	**4**
PHYDMT-902	**Quantum Mechanics-II**	**4**
PHYDMT-903	**Electrodynamics-II**	**4**
PHYDMT-904	**Advanced Solid State Physics**	**4**
PHYDMP-905	**Nuclear Physics Lab**	**2**
PHYDMP-905	**Analogue and Digital Electronics Lab**	**2**
	Total Credits	**20**
	Semester X	
PHYDMT-1001	**(A) Relativistic Quantum Mechanics & Quantum Field Theory** **Or** **(B) Instrumentation Techniques**	**4**
PHYDET-1002	**Elective-1**	**4**
PHYDET-1003	**Elective-2**	**4**
PHYD-1001	**Project Dissertation**	**6**
PHYD-1002	**Seminar/Presentation on the Dissertation**	**2**
	Total Credits	**20**
	List of Electives	
A student has to choose a group of two electives from the following List		
Group-1	**General Theory of Relativity and Cosmology**	
	Astrophysics	

Group-2	**Condensed Matter Physics-I**	
	Condensed Matter Physics-II	
Group-3	**Digital Electronics**	
	Microwave Electronics	
Group-4	**Particle Physics-I**	
	Particle Physics-II	

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

PHYDMT-101 and **PHY**IDMT-103: Mechanics, Waves and Oscillations

Credit(s): 4

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: Relation Between Elastic Coefficients. Twisting Torque on a Cylinder or Wire.

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.

Unit-IV

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-V

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.

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:

Suggested Books

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 McGrawHill, 2007.

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

6. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern Limited,1985.

COURSE OUTCOMES (MECHANICS, WAVE AND OSCILLATIONS)

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

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-5. Understand the basic concept of ultrasonic.

PHYDMP-107 and **PHY**IDMP-108**: Mechanics Lab** **Credit(s): 2**

N.B.: Students are required to perform at least 12 experiments

1. To determine the Young's Modulus using Bar method.
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. Determination of velocity of sound in air by observing standing waves using speaker, microphone and CRO.
11. Study of the random decay and determination of decay constant using statistical board.

Physics Minor-I: MECHANICS (**PHY**DMI-102 and **PHY**DMI-104)

(Credits-02)

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. **(4 Lectures)**

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)**

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 - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum.

(4 Lectures)

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

(4 Lectures)

Note: *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate*

Suggested Readings:

1. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison- Wesley
2. Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. Engineering Mechanics, Basudeb Bhattacharya, 2^{nd} edn., 2015, Oxford University Press
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHYVOT-105: 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.

Unit-II

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-III

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.

Unit-IV

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

Unit-V

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 Books

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

2. Balaguruswami, **Programming in C**, Tata 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 andpractice 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.

PHYVOP-106**: Computational Physics Lab-I** **Credit(s): 2**

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 Books

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

2. Balaguruswami, **Programming in C**, Tata McGraw Hill (2018).

Semester II

PHYDMT-201 and **PHY**IDMT-203**: 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 Thransitions.

Suggested Books

1. Enrico Fermi: Thermodynamics, Courier Dover Publications, 1956.

2. Meghnad Saha, B. N. Srivastava: A Treatise on Heat: Including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics, Indian Press, 1958.

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**.**

PHYDMP-207 and **PHY**IDMP-208**: Thermodynamics Lab** **Credit(s): 2**

N.B.: Students are required to perform at least 8 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.

Physics Minor-II: ELECTRICITY & MAGNETISM
(PHYDMI-202 and PHYDMI-204) (Credits-02)

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). **(8 Lectures)**

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, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(10 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. **(4 Lectures)**

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

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

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

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

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

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

PHYVOT-205: 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.

Unit-II

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-III

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.

Unit-IV

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.

Unit-V

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.

Suggested Books

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.**

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.

PHYVOP-206: Computational Physics Lab-II — Credit(s): 2

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 evaluating 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 Books

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.**

Semester III

PHYDMT-301 and **PHY**IDMT-303**: Electricity and Magnetism** **Credit(s): 4**

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.

Unit-V

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 Books

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.

PHYDMP-307 and **PHY**IDMP-308**: Electricity and Magnetism Lab**

Credit(s): 2

N.B.: Students are required to perform at least 12 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 Books

1. Geeta Sanon: B. Sc. Practical Physics, 1st Edn. (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.

Physics Minor-III: THERMODYNAMICS
(PHYDMI-302 and PHYDMI-304) (Credits-02)

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 and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(12 Lectures)**

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. **(8 Lectures)**

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

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

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

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

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

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

7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.

PHYVOT-305**: Optoelectronics and Photonics** **Credit(s): 4**

Unit-I

Classical Photometry: Introduction.

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.

Unit-II

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.

Unit-III

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.

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.

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.

Unit-V

Holography: Holography versus photography. Basic theory of Holography. Applications of Holography in Microscopy and Interferometry.

Optical Communication: Optical fiber as optical wave-guide. Numerical Aperture and Maximum Angle of Acceptance.

Suggested Books

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.

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**.

PHYVOP-306: Optoelectronics and Photonics Lab Credit(s): 4

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

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

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

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

4. To determine the value of Planck's Constant using a Photoelectric Cell.

5. To determine the value of e/m by using Bar Magnet method.

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

6. To study **Logic Gates** and verify their **truth tables.**

7. To determine the value of Planck's Constant using LEDs of at least 4 different wavelengths.

8. To determine **Resolving power** of **Telescope**.

9. To determine the wavelength of prominent lines of Mercury by using plane **Diffraction Grating**.

10. To determine **Dispersive Power** of a Prism using Mercury light source and **Spectrometer**.

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

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

Semester IV

PHYDMT-401 and **PHY**IDMT-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 Books

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.

PHYDMP-407 and **PHY**IDMP-408**: Electronics Lab** **Credit(s): 2**

N.B.: Students are required to perform at least 12 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).

Physics Minor-IV: WAVES AND OPTICS
(PHYDMI-402 and PHYDMI-404) (Credits-02)

Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) 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)**

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'sDouble 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. **(4 Lectures)**

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. **(4 Lectures)**

Suggested Readings:

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

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

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

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

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PHYVOT-405: Solar Energy and Energy Studies Credit(s): 4

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 geomatary, 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. Transparatent 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.

Unit-IV

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

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. Efficiences in differnet storages.space conditioning.

Unit-V

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

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

Suggested Readings

1. Heat Condution: M. Necati Ozisik-John Wiley & Sons.
2. Hand Book of Heat transfer Application: Edited by Warren M. Rohsenow, James P. Harnou and Ejup N. Ganic.
3. Conduction of Heat in Solids: H.S., Carslas and J.C.Jsegar, Oxford Clarendon Press 1959.
4. Heat and Mass Transfer: A Luikov, Mir Publichers Moscow.
5. Thermal conductivity of Solids: J.E. Parrot and Audrey D. Stuckers : Pion Limited, London.
6. Solar energy Thermal Processs : Dluffie and Backman. Wiley & Sons. New York.
7. Solar Energy Engg.: Jui Sheng Haieh,Prentic Hall, New Jersey.

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.

PHYVOP-406: Energy Studies Lab — Credit(s): 2

1. Complete study of characteristics of Photovoltaic Cells (Solar Cells).

2. To study spectral response measurement using a photovoltaic cell.

3. To study and simulate Solar PV Energy System.

4. To simulate study on Wind Energy Generator.

5. To perform experiment on Performance Assessment of Hybrid (Solar-Wind) Power System**.**

6. To fabricate a solar cell in the laboratory.

7. To perform experiments on the ***Virtual Solar Simulator*** software.

Semester V

PHYDMT-501 and **PHY**IDMT-503**:**

Mathematical Physics & Special Theory of Relativity **Credit(s): 4**

Unit-I

Vector Calculus: Vector Differentiation. Scalar and Vector Fields. Ordinary and Partial Derivative of a Vector w.r.t. coordinates. Space Curves. Unit Tangent Vector and Unit Normal Vector (without Frenet- Serret Formulae). Directional Derivatives and Normal Derivative. Gradient of a Scalar Field and its Geometrical Interpretation. Divergence and Curl of a Vector Field. Del and Laplacian Operators. Vector Identities. Vector Integration**:** Ordinary Integral of Vectors. Line, Surface and Volume Integrals. Flux of a Vector Field. Gauss' Divergence Theorem, Green's Theorem and Stokes Theorem.

Unit-II

Special Mathematical Techniques: Green's Function. Gamma and Beta function. Sterling's formula. **Dirac Delta Function:** Definition. Representation and Properties of Dirac Delta Function.

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

Introduction to Tensors. The idea of covariant, contravariant and mixed tensors of rank 1, 2 and 3. Transformations, Algebra and Calculus of tensors. Christoffel symbols of first and second kind. **The idea of Geodesics**.

Unit-III

Complex Variables: Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy- Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, **Complex integration**.

Analytic continuation.

Saddle Point Function.

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 (1998).

2. L. I. Schiff, Quantum Mechanics, 3rd edition, (McGraw Hill Book Co., New York 1968).

3. E. Merzbacher, Quantum Mechanics, 3rd edition, (John Wiley & Sons, Inc1997)

4. J. L. Powell & B. Crasemann, Quantum Mechanics, (Addison-Wesley Pubs.Co.,1965)

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.

PHYDMP-507 and **PHY**IDMP-508**: Virtual Lab on Special Theory of Relativity and Quantum Mechanics**

Credit(s): 2

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 undergo the following virtual experience on Internet:

V1-V11. Set of virtual experiments on 'Special Theory of Relativity':

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/SpecRel.html

V1. **The Constancy of the Speed of Light**

The Michelson-Morley Experiment

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/MichelsonMorley/MichelsonMorley.html

Einstein "Explains" the Michelson-Morley Experiment

V2. **Exploring the Consequences of Einstein's "Explanation"**

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/Flatland/Flatland.html

V3. Spacetime: Spacetime Diagrams, and The Dimensions of Spacetime

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/SpecRel.html#Surveyors

Further Consequences of Einstein's Explanation

V4. Time Dilation

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/TimeDilation.html

V5. Length Contraction

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/LengthContract.html

V6. Simultaneity

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/Simultaneity.html

V7. Relative Speeds

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/SpecRel.html#RelSpeeds

V8. Mass-Energy Equivalence

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/MassEnergy.html

V9. The "Speed" of Objects

http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/SpecRel.html#RelSpeeds

V10. The Lorentz Contraction is Invisible http://www.upscale.utoronto.ca/GeneralInterest/Harrison/SpecRel/Flash/ContractInvisible.html

V11. Quantifying the Uncertainty

V12. For set of virtual experiments on electron diffraction

http://www.uv.es/inecfis/QPhVL/index.html

Physics Minor-V: Solid State Electronics

(PHYDMI-502 and **PHY**DMI-504**) 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. **(6 Lectures)**

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. **(6 Lectures)**

Unit-III

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-IV

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-V

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, Wiley Eastern.

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

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

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

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

Semester VI

PHYDMT-601 and **PHY**IDMT-603**: Atomic and Molecular Physics**

Credit(s): 2

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 Books

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

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

3. Ghatak and Thyagarajan: Optoelectronics, Oxford University Press.

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.

PHYDMP-607 and **PHY**IDMP-608**: Modern Physics Lab** **Credits: 2**

(Great Experiments in Physics)

Students have to perform any ten 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*.

Suggested Readings

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

Physics Minor-VI: Atomic and Molecular Physics

(PHYDMI-602 and **PHY**DMI-605**)** **Credit(s): 2**

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. **(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). **(6 Lectures)**

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. **(6 Lectures)**

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. **(6 Lectures)**

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. **(6 Lectures)**

Suggested Books

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

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

3. Ghatak and Thyagarajan: Optoelectronics, Oxford University Press.

Semester-VII

PHYDMT-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, Liouvilee'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.

2. L. D. Landau and E.M. Lifshitz: Mechanics, Butterworth-Heinemann.

3. A. Raychoudhary: Classical Mechanics, Oxford University Press

4. N. C. Rana and P. S. Joag: Classical Mechanics, Tata McGraw Hill.

5. Ronald L. Greene: Classical Mechanics with Maple, Springer

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."

PHYDMT-702: **Quantum Mechanics- I** **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

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-III

Time-independent and time-dependent Schrodinger Wave 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.

Applications of Schrödinger Wave Equation

Eigen Functions and Eigenvalues for a Particle in a One Dimensional Box.

(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

Structure of Quantum Mechanics: Postulates of QM, Hilbert space; Hermitian and unitary operators; Orthonormality, completeness andclosure. Dirac's bra and ket notations. Matrix Representation and change of basis. Operators and observables, significance of eigenvector and eigenvalues, Commutation relation; Uncertianity principle for arbitrary Operators.

Unit-V

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

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'.

PHYDMT-703: Classical Electrodynamics – I Credit(s): 4

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.

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

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

4. David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
5. Panofsky & Phillip: Classical electrodynamics and magnetism

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 superpotentials, and make a detailed account for gauge transformations and their use

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

CO4: Calculate the electromagnetic radiation from localised 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, localised charge and current distributions)

PHYDMT-704: 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 thermodyanic 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.
2. K. Huang: Statistical Mechanics, John Wiley & Sons.
3. L. D. Landau and E. M. Lifshitz: Statistical Physics, Butterworth-Heinemann.
4. Richard P. Feynman: Statistical Mechanics, West View Press.

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.

PHYDMP-705: Advanced Physics Lab-1 Credit(s): 2

Students have to perform any ten 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 osciallator*.
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.

PHYDMP-706: Advanced Physics Lab-1 **Credit(s): 2**

Students are required to perform any ten 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 Verdet 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 (2006) PHI Pub.
2. K. V. Raman, R. Raja and M. S. Rajan, Experimental Physics (2014) Scintech Publ.
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.

Semester-VIII

PHYD-801	Dissertation (Four Components carrying 20 Credits)	**20**
PHYD-801A	Lab Work/Field Work/Field Survey/Industrial Visit/Institutional Visit/Data Collection/Internship etc.	**4**
PHYD-801B	Pre-Submission Presentation	**4**
PHYD-801C	Report Writing/Write-up/Dissertation Report	**8**
PHYD-801D	Viva-Voce	**4**

Semester-IX

PHYDMT-901: Nuclear Physics Credit(s): 4

Unit-I: Interaction of radiation and charged particle with matter (No derivation)

Law of absorption and attenuation coefficient; Photoelectric effect, Compton scattering, pair production; Klem-Nishima cross sections for polarized and unpolarized radiation, angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

Unit-II: Nucleon-Nucleon Scattering and Potentials

Partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of the-scattering length, coherent scattering of neutrons by protons in (ortho and para) Hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of Proton- Proton scattering at low energy: General features of two-body scattering at high energy Effect of exchange forces: Phenomenological Hamada- Johnston hard core potential and Reid hard core and soft core potentials; Main features of the One Boson Exchange Potentials (OBEP) no derivation.

Unit-III: Two Nucleon system and Nuclear Forces

General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, central, noncentral and velocity dependent potentials, Analysis of the ground state (3S1) of Deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of Deutron under noncentral force, calculation of the electric quadru-pole and magnetic dipole moments and the D-state admixture.

Experimental Techniques: Gas filled counters; Scintillation counter, Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detectors; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerations; Acceleration of heavy ions.

Unit-IV: Nuclear Shell Model

Single particle and collective motions in nuclei: Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric-quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units: Nuclear isomerism.

Unit-V: Collective Nuclear Model

Collective variable to describe the cooperative modes of nuclear motion; Parametrization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of, inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.

Nuclear gamma and beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations), Reduced transition probability, Selection rules; zero- zero transition. General characteristics of weak interaction; nuclear beta decay and lepton capture; electron energy spectrum and Fermi- Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gammaw-Teler) for allowed transitions; ft-values; General interaction Hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions ,Experimental verification of parity violation; The V-A interaction and experimental evidence.

Suggested Readings

1. J. M Blatt and V. E. Weisskipf: Theoretical Nuclear Physics.
2. R. D. Evans: The Atomic Nucleus, McGraw-Hills, 1955.
3. H. Enge: Introduction to Nuclear Physics, Addition-Wesley, 1970.
4. E. Segre: Nuclei and Particles, Benjamin, 1977.
5. W. E. Burcham: Elements of Nuclear Physics, ELBS, Longman, 1988.
6. B. L. Cohen: Concpt of Nuclear Physics, Tata Mc-Graw Hills, 1988.
7. I. Kaplan: Nuclear Physics, Addison Wesley, 1963.
8. R. M. Singru: Introductory Experimental Nuclear Physics.
9. M. K. Pal: Nuclear Structlire: Affiliated East-West Press, 1982.
10. R. R. Roy and B. P. Nigam: Nuclear Pbysics, Willey-Easter, 1979.

Course Outcome (CO) of Nuclear Physics

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

CO-1: Understand basic Nuclear Physics properties.

CO-2: Understand basic properties of nucleus and develop nuclear models.

CO-3: Understand Nuclear reaction dynamics and apply wherever applicable.

CO-4: Analyse the properties of nuclear structure and apply it in nuclear research.

CO-5: Understand nuclear reactions and apply it in the nuclear power generation.

PHYDMT-902**: Quantum Mechanics- II** **Credit(s): 4**

Unit-I

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-II

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

Unit-III

Density Matrices: Basic definition and properties. Pure and Mixed states.

Quantum Entanglement and Quantum Teleportation (Introduction)

Quantum Computing: Basic Idea of Quantum Computation and Quantum Information Theory.

Unit-IV

Approximation Methods

Time Independent Approximation Methods: Variational Methods, WKB method, tunneling.
Perturbation Theory: Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples.

Unit-V
Time-dependent Perturbation Theory: Interaction Picture;Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example.

Scattering Theory: Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

Unit-V
Symmetries in Quantum Mechanics: Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy.

Identical Particles: Meaning of identity and consequences; Symmetric and anti-symmetric wavefunction; incorporation of spin, symmetric and antisymmetric spin wave function of two identical particles, Slater's determinant, Pauli exclusion principle.

Suggested Readings

1. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe: Quantum Mechanics, Wiley.
2. Albert Messiah: Quantum Mechanics, Dover Publications.
3. S. Flugge: Quantum Mechanics, Springer.
4. L. I. Schiff: Quantum Mechanics, Mc-Graw Hill.
5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.
6. E. Merzbecher: Quantum Mechanics, John Wiley.

Course Outcome (CO) of Quantum Mechanics-II

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

CO-1: Understand the idea of 'Quantum Computers', 'Quantum Entanglements' and contribute to in the development of 'Quantum Information Theory'.

CO-2: Understand various 'Time Independent Approximation Methods in Physics' such as 'WKB Approximation', 'Variational Method', and ''.

CO-3: Understand 'Time Dependent Perturbation Methods' and further explore the transitions.

CO-4: Understand nitty-gritty of 'scattering theory' and apply it in the properties of matter.

CO-5: Understand 'symmetries in Quantum Mechanics' and apply it in the advanced research.

PHYDMT-903**: Classical Electrodynamics-II** **Credit(s): 4**

(Classical Electrodynamics in Matter and Medium)

Unit-I

Special techniques for calculating potentials

Laplace's Equation: Laplace's equation in one dimension. Laplace's equation in two dimensions. Laplace's equation in three dimensions. Boundary conditions and Uniqueness theorems. Conductors and second uniqueness theorem

Unit-II

The Method of Images: The classic image problem. The induced surface charge. Other image problems

Multi-pole Expansion: Approximate potentials at large distances. The monopole and dipole terms. Origin of coordinates in multi-pole expansion. The electric field of an electric charge

Unit-III

Electro-magnetic waves in conducting and non-conducting media

Electro-magnetic waves in non-conducting media: Monochromatic plane waves in vacuum. Energy and momentum of electro-dynamic waves. Propagation through linear media. Reflection and transmission at normal and oblique incidence

Unit-IV

Electromagnetic Waves in Conductors: The modified wave equation. Monochromatic plane waves in conducting media. Reflection and transmission at conducting surface

Dispersion: The frequency dependence of ε, μ and σ . Dispersion in non-conductors. Free electrons in conductors and plasma

Guided Waves and Transmission Lines: Wave guides. TE waves in rectangular wave-guides. The coaxial transmission lines

Unit-V

Magneto-Hydrodynamics and Plasma Physics

Introduction and definitions. MHD equations. Magnetic Diffusion: Viscosity and Pressure. Pinch effect: instabilities in pinched plasma column. Magneto-hydrodynamics waves. Plasma Oscillations: Short wave length limit of plasma oscillations and Debye shielding distance

Suggested Readings

1 L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press.
2 L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press.
3 J. D. Jacksson: Classical Electro-dynamics; John Wiley.
4 David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
5 Panofsky & Phillip: Classical electrodynamics and magnetism.
6 N. N. Rao: Elements of Engineering Electromagnetics, Pearson Education.

Course Outcome (CO) Electrodynamics-II

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 superpotentials, and make a detailed account for gauge transformations and their use

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

CO4: Calculate the electromagnetic radiation from localised 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, localised charge and current distributions)

PHYDMT-904: Advanced 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. Charles Kittel, Introduction to Solid State Physics, 7th Edition, John Wiley and Sons, Inc.

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

3. J. S. Blackmore, Solid State Physics, Cambridge University Press, Cambridge.

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

5. S. O. Pillai, Solid State Physics, Wiley Eastern.

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.

PHYDMP-905**: Nuclear Physics Lab** **Credit(s): 2**

(Experiments in Nuclear Physics)

Students have to perform any eight experiments from the following:

1. To study G.M. detector characteristics and determine operating voltage of a G.M. tube.
2. To study random nature of radioactive decay using G.M. counter.
3. To determine the resolving time of G.M. counting set up (single and double source methods).
4. To study the absorption of β - particles and determine end point energy using G.M. counter.
5. To determine absorption coefficient of γ - rays.
6. Study of secular equilibrium in radioactive decay.
7. To determine end point energy of β - particles using Scintillation counter.
8. To study Compton scattering of γ - rays using Scintillation counter.
9. Study of absorption curve of α - particles using semiconductor detectors.
10. Study of specific energy loss and straggling of α - particles using semiconductor detectors.

Suggested Readings

1. Nuclear Detectors: Knoll.
2. Experimental Nuclear Physics: S.S. Kapoor and Ramamurthy; Tata McGraw Hill.

PHYDMP-906**: Analogue and Digital Electronics Lab** **Credit(s): 2**

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 microprocessors 8085 and 8086 and their applications.

12. To study analogue to digital and digital to analogue conversion.

13. To design and fabricate a ‘digital electronic’ circuits. (Mini Project)

Suggested Readings

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

Semester-X

PHYDMT-1001A: Relativistic Quantum Mechanics and Quantum Field Theory

Credit(s): 4

Unit-I: Relativistic formulation of Quantum Mechanics

Klein-Gordon equation. Covariance and solution of Klein-Gordon equation. Dirac’s equation. Covariance and solution of Dirac’s equation. Symmetries of Dirac’s equation. Bilinear covariants.

Unit-II: Quantum Fields

Classical Lagrangian field theory, 'Euler-Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, second quantization, of identical bosons, second quantization of the real Klein Gordan field and complex, Klein-Gordan field, the meson propagator.

Unit-III

The occupation number representation for fermions, second quantization of the Dirac filed, the femion propagator, the electromagnetic interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

Unit-IV

S-matrix formulation: *S*-matrix expansion. Wick's theorem. Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED.

Path Integral Formalism: Applications

Unit-V

Specific Processes: Applications of *S* matrix formalism: the Coulomb scattering, Bhabha scattering, Moller scattering, Compton scattering and pair production. Weak interaction by means of V-A theory.

Suggested Readings

1. F. Mandal & G. Shaw: Quantum Field Theory, John Wiley.

2. J. M. Ziman: Elements of Advance Quantum Theory, Cambridge University Press.

PHYDMT-1001B: Instrumentation techniques **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, Calss-E, Class-F commutation circuits. Series and parallel operation of thyristors, protection of thyristors : di/dt protection, dv/dt protection, design of snubber circuit, overvoltage protection, over current protection.

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. A Course in Elec. & Electronic Measurement and Instrumentation: A.K. Sawhney Dhanpat Rai & Sons, New Delhi, 1995.
2. Electronic Instrumentation and measurement techniques: W.O. Cooper, Prentice Hall of India Limited, New Delhi, 1992.
3. Electronic measurement & Instrumentation systems: Larry Jones & A foster Chin
4. Electronic measurement & measuring Instruments: Golding & Waddis A H Wheeler & Company, Calcutta, 1993.
5. Instrumentation Devices & Systems : C.S. Rangan, G.R. Sarma, V.S.V. Mani, 2nd Edition, Tata McGraw Hill publishers.

6. Instruments and Transducers: D.V.S. Murty, PHI.
7. Power Electronics: M.H. Rashid, Pearson Publication
8. Cengage Power Electronics Principles and Applications: Jacob, Learning.
9. Power Electronics: V.R. Murthy, Oxford Publication

Syllabi of Elective Papers for Semester-10

(PHYDET-1002 and PHYDET-1003)

Group-1A: General Relativity and Cosmology **Credit(s): 4**

General Theory of Relativity

Principle of equivalence. Metric formulation and tensor nature of gravitational field. Geodesic motion in curved space-time.

Gradient, divergence, curl, and curvature and torsion in General Relativity. Bianchi identity and curvature tensor.

Einstein’s field equation and gravitation. Schwarzchild metric and solutions of Einstein’s equation.

Three crucial tests of Einstein’s theory of gravitation. Killing vectors. Theory of gravitational waves.

Singularities of Schwarzchild metric and Penrose diagrams. Ray-Chaudhary equation.

Cosmology

Einstein's model of Universe. De-Sitter Universe.

Friedman-Robertson-Walker-Lemaitre model of the Universe. Big-Bang and the Physics of the early Universe. Particle and the Nucleo-synthesis in the early Universe. Various phase transitions and time-line of the Universe.

Inflationary cosmology and generation of density perturbations. Alternative cosmologies: Quasi-Steady State Theory of the Universe.

Suggested Readings

1. S. Weinberg: General Relativity, Gravitation and Cosmology, Wiley.

2. Peacock J. A.: Cosmological Physics, Cambridge University Press.

3. Meissner, Kip Thorn and John Wheeler, Gravitation and Cosmology, Benjamin Feeman.

4. J. V. Narlikar: Introduction to Cosmology, Cambridge University Press.

Group-1B: Astrophysics **Credit(s): 4**

Astrophysics: Overview

The structure, origin, and evolution of the major components of the Universe: planets, stars, and galaxies. Formation of the Sun and planets.

Luminosity and magnitudes of stars. Saha'a ionisation equation.

Astrophysical processes: Basics of electromagnetic radiations; Statistical mechanics of Astrophysical phenomena; Radiative processes; Spectra; Neutral fields and plasma in Astrophysics.

Stellar evolution; X-ray sources, Binary stars, Pulsars, Quasars and other compact stars. The origin and search for life in the Universe.

Structure Formation and the Evolution of the Universe

Structure formation in the early Universe. Galaxy formation. Elliptical and spiral galaxies. Rotational curves of galaxies and signatures of dark matter. Physics of the inter-stellar and inter-gallactic media. Star formation. Radiative transfer and stellar mechanics. Chandrashekhar limit and life-cycles of stars: Supernovae-Adult stars-Red Giants-Black Holes/White Dwarfs. The idea of White holes and Brown Dwarfs.

Suggested Readings

1. Arnab Rai Chaudhary: Astrophysics for Physicists, Cambridge University Press.

2. T. Padmanabhan: Theoretical Astrophysics-I, Cambridge University Press.

3. T. Padmanabhan: Theoretical Astrophysics-II, Cambridge University Press.

4. T. Padmanabhan: Theoretical Astrophysics-III, Cambridge University Press.

Group-2A: Condensed Matter Physics-I Credit(s): 4

Structure Factor: Static structure factor and its relation with the pair correlation function. Determinationof structure factor by X-ray and neutron scattering. Inelastic neutron scattering and dynamic structure factor, space time correlation function and its relation with dynamic structure factor, properties of space time correlation function. Langevin's equation for Browninan Motion and its modifications. Velocity autocorelatiion function, mean square displacement, Relation between velocity autocorelation function and diffusion coefficient.

Liquid Metals: Metallic interactions-Kinetic energy, electrostatic exchange and correlation, Pseudopotential formalism, diffraction model, structure factor, form factor for local and nonlocal potentials, energy eigen states, dielectric screening. Energy wave number characteristics, calculation of phonone dispersion of liquid metals. Band structure energy in momentum and direct space. Ziman's resistivity formula, Green function method for energy bands in liquid metals.

Quantum Liquids: Distinction between classical and quantum liquids, critetria for freezing, phase diagram of He4, He I and He II Tisaza's two fluid model, entropy filter, Fountain effect, superfluid film vehicle, Viscosity and specific heat of He4, first sound, second sound, third sound and fourth sound, Landau theory: Rotons and Phonis, t-matrix theory of superfluid He. Basic differences in superfluidity in He3 and He4.

Exotic Solids: Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonanccy sequency, Penrose lattices and their extension to 3-dimensions, Special carbon solids. Fullerences and tubules; formation and characterization of fullerences and tubules. Single wall and multivwall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic based devices Definition and properties of nanostrctured materials. Methodsof synthesis of nanostructured materials. Special experimental techniques for characterization of nanostrcutred materials. Quantum size effect and its applications.

References Books

1. Egelestaff: In Introduction to the Liquid State (Chapters 2, 3, 5, 6, 7 and 8.)
2. Hansen and McDonald : Theory of Simple Liquids, (Chapters 3, 5, 7, and 9).
3. D. Pines and P. Nozier: The Theory of Quantum Liquid.
4. W.A. Harison: Pseudopotentials in the Theory of Metals Benjamin.
5. March, yound and Saupenthe - Many Body Problems.

6. March and Tosi: Atomic Motions in Liquids.
7. March, Tosi and Street: Amorphous Solids and the Liquid State, Plenum, 1985.
8. Dugdale: Electrical Properties of Metals an Alloys.

Group-2B: Condensed Matter Physics-II Credit(s): 4

Phase Transformation and Alloys: Equilibrium transformation of first and second order. Equilibrium diagrams. Phase rule. Interpretation of phase diagrams. Substitutional solid solutions. Vegard's law, intermediate phases, Hume-Rothery rules. Interstitial phases (carbides, nitrides, hydrides, borides). Martensitic transitions. structure factor of liquid metal alloys, behaviour of s(q), radial distribution function g(r) and relationship between s(q) and g(r)

Disordered Systems: Disorder in condensed Matter, Substitutional, positional and topographical disorder. Short adn long range order. Spinning, sputtering and ion-implantation techniques, glass Transiton, glass formatino ability, nucleation and growth processess. Anderson model for random system and electron localization, mobility edge, qualitative application of the idea of amorphous semicodnuctors and hopping conduction. Metglasses, Models for structure of metalglasses. Structure factor of binary metallic glasses and it relationship with the radial distribution functinos. Discussion of electric, magnetic and mechanical properties of glassy system.

Structure determination/characterization: Basic theory of X-ray diffraction. Indexing of Debye-Scherer patterns powder samples, examples from some cubic and non-cubic symmetries. Neutron diffraction-basic interactions, corss section, scatterign length and structure factor. Mossbauer effect, hyperfine parameters-Isomer shift, quadrupole splittign and Zeeman splitting. Application 0Valence adn corrdiantin, site symmetry magnetic behaviour. Discussion in context of Fe57.

Electronic Structure Determination: Basic principles of X-ray, photo-emission and positron annihilation techniques. qualitative discussion of experimental arrangement and typical results for both simple as well as transition metals.

Suggested Readings **(for Condensed Matter Physics I & II)**

1. Egelstaff: An introduction to the liquid state (Chapters 2, 3, 5, 6, 7 and 8).
2. Hansel and Mc Donald: Theory of Simple liquids (Chapters 3, 5, 8 and 9).
3. D.Pines and P. Nozier- The theory of quantum liquids.
4. W.A. Harison: Pseudo potentials in the theory of metals.
5. March, Yound and Saupenthe: Many Body Problems.
6. March and Tosi: Atomic Motins in Liquids.
7. March, Tosi and Street: Amorphous solids and the Liquids State, Plenum, 1985.
8. Dugdale: Electrical Properties of Metals and Alloys.
9. M. Shimoji: Liquid Metals.
10. P.I. Taylor: A. Quantum Approach to the Solid State, Prentice Hall.

Group-3A: Digital Electronics **Credit(s): 4**

Analog Circuits: Integrated Circuits (Qualitative Treatment only): Active and Passive components. Discrete Circuit Component. Wafer. Chip. Advantages and Drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (Basic Idea and Definitions Only). Classification of ICs. Fabrication of Components on Monolithic ICs. Examples of Linear and Digital ICs.

Operational Amplifiers (Use Black Box approach): Basic Characteristics of Op-Amps. Characteristics of an Ideal Op-Amp. Feedback in Amplifiers . Open-loop and Closed-loop Gain. Frequency Response. CMRR. Virtual ground.

Applications of Op-Amps: (1) Inverting and Non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Unity follower, (5) Differentiator, (6) Integrator, (7) Zero Crossing Detector.

Timers (Use Black Box approach): 555 Timer and its Applications: Astable and Monostable Multivibrator.

Digital Circuits: Difference Between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND AND NOR Gates. Exclusive OR and Exclusive NOR Gates.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Data processing circuits: Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders, Parity Checkers.

Memories: Read-only memories (ROM), PROM, EPROM.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement Method).

Half Adders and Full Adders and Subtractors (only up to Eight Bits).

Sequential Circuits: RS, D, and JK Flip-Flops. Level Clocked and Edge Triggered Flip-Flops.

Preset and Clear Operations. Race-around Conditions in JK Flip-Flops. Master-Slave JK Flip-

Flop (As Building Block of Sequential Circuits).

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

Counters: Asynchronous and Synchronous Counters. Ring Counters. Decade Counter. D/A and A/D conversion: D/A converter – Resistive network. Accuracy and Resolution.

Suggested Books

1. D. P. Leach & A. P. Malvino: Digital principles and applications (Glencoe, 1995).

2. Thomas L. Floyd: Digital Fundamentals, 3rd Edition, Universal Book Stall, India, 1998.

3. Robert F Coughlin and Frederick F Driscoll: Operational Amplifiers and Linear Integrated Circuits, 4th Edition, PHI, 1992.

4. R. A. Gayakwad: Op-Amps and Linear Integrated Circuits, Pearson, 2000.

Group-3B: Microwave Electronics and Communication Credits: 4

Microwave Wave Guides: Rectangular wave guides: TE, TM and TEM modes in wave guides, power transmission in wave guide, power losses in wave guide, excitation modes in wave guide, Characteristics of standard wave guides.

Microwave Components: microwave cavities, microwave attenuators, Scattering parameters, E-H tunner, directional coupler, circulators and isolators, Phase shifter.

Microwave Tubes: Linear beam: klystrons, reflex klystrons, TWTs. Microwave Crossed Field Tubes: Magnetrons, forward wave crossed field amplifier (FWCFA), high power gyrotrons. (Operating principle, construction & analytical treatment of above mentioned microwave tubes.)

Microwave Solid State Devices: Microwave tunnel diodes, microwave FETs, gunn effect diodes, RWH Theory, LSA diodes, Impatt diodes, PIN diodes, ruby laser, MESFETs and HEMT. (Operating principle, construction and analytical treatment of above mentioned microwave devices.)

Microwave Measurements: Detection of microwave power: measurement of microwave low and high power, thermister parameters, thermister mounts, barreters, direct reading barreters bridges, Measurement of wavelengths: single line cavity coupling system, Transmission cavity-wave meter and reaction wavemeter, measurement of VSWR, measurements of attenuation, input impedance.

Microwave Antennas: Different types of antennas.

Modulation and Demodulation: Types of Modulation. Amplitude Modulation. Modulation Index. Analysis of Amplitude Modulated Wave. Sideband Frequencies in AM Wave. CE Amplitude Modulator. Demodulation of AM Wave using Diode Detector. Idea of Frequency, Phase, and Digital Modulation.

Suggested Readings

1. R.E.Collin: Foundation of Microwave Engg, McGraw Hill.

2.Samul Liao: Microwave Devices and Circuit, PHI.

3. Sisodia and Raghuvanshi: Microwave Circuits and Passive Devices, Wiley Eastern.

4. David M. Pozar, Microwave Engineering, JohnWiley& Sons, Inc.

5. Roddy.D.: "Microwave Technology" Reston Publications (1986).

6. Chatterjee R. "Microwave Engineering "East West Press (1988).

7. Rizzi.P."Microwave Engineering Passive circuits". Prentice Hall (1987).

8. Clock.P.N. "Microwave Principles and Systems" Prentice Hall (1986).

Group-4A: Particle Physics- I **Credit(s): 4**

Elementary particles and the fundamental forces. Quarks and leptons. The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; particle acceleration, and detection techniques. Symmetries and conservation laws.

Bound states. Discoveries and observations in experimental particle physics and relation to theoretical developments. Symmetries, group theory, The gourp SU(2), Finite Symmetry Group: P and C, SU(2) of Isospin, The group SU(3)

Quark and Antiquark states: Mesons, Three quark states:Baryon, color factors, Asymptotic freedom. Charged and neutral weak interactions. Electroweak unification.

Decay rates and Cross sections: Feynman diagrams Introduction to Feynman integrals. The Dirac equation. Feynman rules for quantum electrodynamics (no derivation). Moller scattering, trace theorems and properties of gamma matrices, helicity representation at high energies., the electron propagator, the photon propagator.

Structure of Hadrons: form factors, e-p scattering, inelastic e-p scattering, Bjorken scaling, Partons, gluons, deep inelastic scattering, evolution equations for parton densities.

QCD: Electron positron annihilation into hadrons, heavy qwuark production, three jet events, QCD corrections, Perturbative QCD, Drell-Yan process

Weak Interactions: Parity violation, V-A form of weak interaction, Nuclear beta decay, muon decay, pion decay, charged curre nt neutrino electron scattering, neutrino quark scattering, weak neutral currents, the Cabibo angle, weak mixing angles, CP invariance.

Suggested Readings

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
2. B.R. Martin and G. Shaw, Particle Physics, 2nd edition, J. Wiley and Sons (1997).
3. The Review of Particle Physics, (Particle Data Group)
4. David Griffiths: Introduction to Elementary Particles.
5. Byron Roe: Particle Physics at the New Millennium.
6. Donald Perkin: Introduction to high energy physics.

Group-4B: Particle Physics- II **Credit(s): 4**

Gauge Symmetries: U(1) Local gauge invariance and QED, Non-abelian gauge invariance and QCD, mnassive gauge bosons, spontaneous breakdown of symmetry, the Higgs mechanism.

Local gauge invariance and Yang-Mills fields: Lagrangian of the Spontaneous symmetry breaking and the Higgs mechanism, The Weinberg-Salam model and beyond.

Standard Model of Particle Physics: Unified models of weak and electromagnetic interactions, flavor group, flavor-changing neutral currents. Weak isospin.

Quark and lepton mixing: CP violation. Neutrino oscillations.CKM quark mixing matrix, GIM mechanism, rare processes, neutrino masses, seesaw mechanism

QCD confinement and chiral symmetry breaking, instantons, strong CP problem

Suggested Readings

1. Francis Halzen and Allan D. Martin, **Quarks and Leptons: An Introductory Course in Modern Particle Physics,** John Wiley and Sons
2. B.R. Martin and G. Shaw, **Particle Physics**, 2nd edition, J. Wiley and Sons (1997).
3. Particle Data Group, **The Review of Particle Physics**,
4. David Griffiths, **Introduction to Elementary Particles**
5. Byron Roe **Particle Physics at the New Millennium**
6. Donald Perkin, **Introduction to high energy physics**).
7. Martin and Shaw, **Particle Physics**

PHYD-1001: Project (Dissertation) Credit(s): 6

Work with any University/ Academic Institution/ Research Lab/Eminent Professor

PHYD-1002: Seminar (Presentation of Project Work) Credit(s): 2