FYUGP SYLLABUS (UNDER NEP-2020) OF THE DEPARTMENT OF PHYSICS MADHABDEV UNIVERSITY

Approved in the meeting of the Board of Studies of the Department of Physics held on June 24, 2023

Members Present

Sl no	Name of the member	Signature
1.	Dr. Limpon Bora, Academic Registrar, MDU	
2.	Dr. Arindam Phukan HoD, Dept. of Physics, MDU	
3.	Dr. Lakhinath Borah Member, Dept. of Physics, MDU	
4.	Prof. Mrinal Kumar Das External member HoD, Dept. of Physics Tezpur University	
5.	Dr. Nilamoni Saikia External member Associate Professor, Dept. of Physics Chaiduar college	
6.	Dr. Lakhi Buragohain External member Associate Professor, Dept. of Physics Chaiduar college	

Program Learning Outcomes in B.Sc (Honours) Physics

The student graduating with the Degree B.Sc (Honours) Physics should be able to acquire

(i) A fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology;

(ii) Procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

(iii) Skills in areas related to one's specialization area within the disciplinary/subject area of Physics and current and emerging developments inthe field of Physics. Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.

Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics. Demonstrate relevant generic skills and global competencies such as

(i) Problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;

(ii) Investigative skills, including skills of independent investigation of Physics-related issues and problems;

(iii) Communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) Analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Physics and ability to translate them with popular language when needed;

(v) ICT skills;

(vi) Personal skills such as the ability to work both independently and in a group. Demonstrate professional behavior such as

(i) Being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

(ii) The ability to identify the potential ethical issues in work-related situations;

(iii) Appreciation of intellectual property, environmental and sustainability issues; and

(iv) Promoting safe learning and working environment.

FYUG Program Structure
Dept. of Physics
Madhabdev University

Year	Semester	Course	Titleof theCourse	Total Credits
Year 01	1st Semester	**C-1**	Physics I	4
		Minor1	Physics I (for disciplines other than Physics)	4
		MDC-1	Natural Science (Physics for All)	3
		AEC- 1	Life skills	4
		VAC-1	Yoga/ NSS/sports and Physical Education	2
		SEC-1	Lib & Info sources/Computer Operating system/Introduction to communication	3
	Total of Semester1			**20**
	2ndSemester	**C-2**	Physics II	4
		Minor2	Physics II (for disciplines other than Physics)	4
		MDC-2		3
		AEC- 2	MIL/ALT.E/Madhabdev Studies	4
		VAC-2	Basic Yoga/ NSS/ Rover & Ranger	2
		SEC-2	Library /Digital Literacy	3
	Total of Semester2			**20**
	Grand Total (Semester 1and 2)			**40**

Students on exit shall be awarded Undergraduate Certificate (in the field of study/discipline) after securing the requisite 40 credits in Sem 1 and 2 provided they secure 4 credits in work based vocational courses offered during summer term or internship/ apprenticeship in addition to 6 credits from skill based courses earned during 1st and 2nd Semester.				
Year 02	**3rd Semester**	**C-3**	Mathematical Physics-I	4
		C-4	Lab-I	4
		Minor3	Thermal Physics and Statistical Mechanics(for disciplines other than Physics)	4
		MDC-3		3
		VAC-3	Environmental Studies	3
		SEC-3	Cyber Security	4
	Total of Semester 3			**22**
	4th Semester	**C-5**	Wave and Optics	4
		C-6	Thermal Physics	4
		C-7	Electronics-I	4
		C-8	Lab-II	4
		Minor4	Lab-I (for disciplines other than Physics)	4
			Internship	2
	Total of Semester4			**22**
	Grand Total(Semester1 to4)			**84**
Students on exit shall be awarded Undergraduate Diploma (in the field of study/ discipline) after securing the requisite 84 credits on completion of Sem4 provided they secure additional 4 credits in skill based vocational course offered during 1st year or 2nd year summer term				

Year 03	**5th Semester**	**C-9**	Mathematical Physics-II	4
		C-10	Quantum Mechanics-I	4
		C-11	Classical Dynamics	4
		C-12	Lab III	4
		Minor5	Wave and Optics	4
			Internship	2
	Total of Semester 5			**22**
	6th Semester	**C-13**	Statistical Mechanics	4
		C-14	Solid State Physics-I	4
		C-15	Nuclear and Particle Physics	4
		C-16	Lab IV	4
		Minor-6	Elements of Modern Physics	4
		Project / Seminar		2
	Total of Semester6			**22**
	Grand Total (Semester1 to 6)			**128**

Students on exit shall be awarded Bachelor of (in the field of study/discipline) Honours (3years) after securing the requisite128 credits on completion of Semester6

<table>
<tr><td rowspan="15">Year4</td><td rowspan="6">Semester7</td><td>C-17</td><td>EMT</td><td>4</td></tr>
<tr><td>C-18</td><td>Electronics-II</td><td>4</td></tr>
<tr><td>C-19</td><td>Experimental Techniques</td><td>4</td></tr>
<tr><td>Minor-7</td><td>Electronics and Solid-State Physics</td><td>4</td></tr>
<tr><td>SEC</td><td>Research Ethics and Methodology</td><td>4</td></tr>
<tr><td>Internship /Project</td><td>Research Project (Development of Project /Research proposal, Review of related literature)/DSE Course in lieu of Research Project</td><td>4</td></tr>
<tr><td colspan="3">Total of Semester 7</td><td>24</td></tr>
<tr><td rowspan="5">Semester 8</td><td>C-20</td><td>Atomic and Molecular Physics</td><td>4</td></tr>
<tr><td>C-21</td><td>Quantum MechanicsII</td><td>4</td></tr>
<tr><td>C-22</td><td>Lab-V</td><td>4</td></tr>
<tr><td>Minor8</td><td>Lab-II</td><td>4</td></tr>
<tr><td>Internship /Project</td><td>Dissertation(CollectionofData,AnalysisandPreparationofReport)/
DSECoursesin lieuofDissertation</td><td>8</td></tr>
<tr><td colspan="3">Total of Semester8</td><td>24</td></tr>
<tr><td colspan="3">Grand Total (Semester1to8)</td><td>176</td></tr>
<tr><td colspan="5">Students on exit shall be awarded Bachelor of (in the field of study/discipline) Honours (4years)/Honours with Research (4 years)after securing the requisite 176 credits on completion of Sem 8</td></tr>
</table>

Syllabus for FYUGP:
Semester: I
(CORE-1)

Paper Name: Physics I **Credit:4**
Paper code: PHYM 101

Course Objectives: The course will enable the student to
1. To have a conceptual understanding of frame of references and related transformations.
2. To realize the reduction of a two body problem to a one body problem in central force system.
3. To appreciate the theory of relativity for particles having relativistic speed.
4. To understand the physics of rigid body.
5. To have a conceptual realization of elastic behavior of matter and to have a theoretical and practical understanding of surface tension and viscosity.
6. To have a detailed analytical understanding of vector algebra with proper knowledge of curvilinear co-ordinate.

Unit I: Newtonian Mechanics:

Concept of frame of references (Inertial and non inertial), Review of Newton's laws of motion, Galilean Transformation and Galilean invariance, two body problem, reduction of two body problem to one body problem, Centre of mass, angular momentum and torque, angular momentum of a system of particles about their Centre-of mass, principle of conservation of angular momentum, Impulse.

Force, Work and Energy and Gravitation: Conservative and Non conservative force, Work-Energy Theorem, Work done in conservative field, conservative force as potential gradient, Elastic and Inelastic collisions. Laboratory and Centre-of-mass reference frames.

Central force, Motion of a particle under central force field, Gravitational field and potential, calculation of gravitational field and potential due to spherical shell and solid sphere. Kepler's laws, satellites in a circular orbit and applications, Geosynchronous orbits, Weightlessness, Basic idea of Global Positioning System (GPS).

Special Theory of Relativity: Michelson-Morley experiment and its outcomes, postulates of special theory of relativity, Lorentz Transformation, Length contraction, Time dilation, variation of mass with velocity, Mass-Energy Equivalence, Relativistic addition of velocities. **(35 marks 30 L)**

Unit-II: Properties of Matter:

Equation of motion of rotating rigid bodies, moment of inertia, theorems of Moment of Inertial, Calculation of M.I of a circular lamina, a solid cylinder, a hollow sphere and a solid sphere. Kinetic Energy of Rotation, Motion involving both translation and rotation.Theory of compound pendulum and determination of 'g'.

Elasticity: Hooke's law- Stress Strain diagram, Young modulus, Bulk modulus and Modulus of Rigidity, Poisson's ratio, relation between elastic constants, bending of beam, the cantilever, work done in stretching and work done in twisting a wire-Twisting couple on a cylinder.

Surface Tension and Surface Energy,angle of contact, rise of liquid in a capillary tube.Viscosity: Streamline flow, turbulent flow, equation of continuity, determination of co-efficient of viscosity by Poiseuille's method, Stoke's method. **(17 marks 15 L)**

Unit-III: Mathematical Physics:

Vector Calculus: Elements of vector calculus, Properties of vector under rotation, Scalar and Vector fields.

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

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian.Notion of infinitesimal line, surface and volume elements.Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. (18 **marks 15 L)**

Reference books:

- Mechanics D.S.Mathur, S. Chand & Co
- Elements of Properties of Matter, D.S.Mathur, S. Chand & Co
- Properties of Matter, Brijlal and Subramaniam.
- Mechanics (In SI Units): Berkeley Physics Course Vol 1 Charles Kittel, Walter Knight, et al Tata McGrawHill 2007
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
- Mathematical Physics, Dass and Verma.S. Chand & Co

Expected learner outcome: This course will

1. Introduce the students to the basic concepts of mechanics.
2. Enable students to get a vast idea of conservation laws and its correlation with nature and symmetry.
3. Enable the students to understand different properties of matter with realization.
4. Develop analytical skills to solve vector algebra with application to physics.
5. Develop knowledge of special relativity to understand relativistic formulation of modern theories.

Semester: II

Core-2

Paper Name: Physics II

Paper code: PHYM 201 **Credit:4**

Course Objectives: The course will enable the student to

1. To have a detailed knowledge about electric and magnetic field.
2. To have an idea about formulation and application of dielectric properties of matter.
3. To acquire a clear understanding of magnetic properties of matter.
4. To understand origin of the Maxwell equations.
5. Apply various network theorems such as Superposition, Thevenin, Norton, Reciprocity, Maximum Power Transfer, etc. and their applications in electronics, electrical circuit analysis, and electrical machines.

Unit-I: Electric Field and Electric Potential (22 marks)

Electric field: Electric field lines. Electric flux.Gauss' Law with applications to charge distributionswith spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field.Electrostatic Potential.Laplace's and Poisson equations.The Uniqueness Theorem.Potential and Electric Field of a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges.Electrostatic energy of a charged sphere.Conductors in anelectrostatic Field. Surface charge and force on a conductor. Capacitance of a system of chargedconductors.Parallel-plate capacitor.Capacitance of an isolated conductor.Method of Images and itsapplication to (1) Plane Infinite Sheet and (2) Sphere. **(20 L)**

Unit-II: Dielectric Properties of Matter: (12 marks)

Electric Field in matter.Polarization, Polarization Charges.Electrical Susceptibility and DielectricConstant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vectorD. Relations between E,P and D. Gauss' Law in dielectrics. **(10 L)**

Unit-III: Magnetic Field and Magnetic Properties of Matter: (16 marks)

Magnetic force between current elements and definition of Magnetic Field B.Biot-Savart's Law andits simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and itsDipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1)Solenoid and (2) Toroid. Properties of **B:** curl and divergence. Vector Potential. Magnetic Force on(1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in auniform Magnetic, Field. Magnetization vector **(M).** Magnetic Intensity**(H).**Magnetic Susceptibility and permeability.Relationbetween **B, H, M**. Ferromagnetism**.B-H** curve and hysteresis. **(15 L)**

Unit-IV: Electromagnetic Induction: (5 marks)

Faraday's Law.Lenz's Law.Self-Inductance and Mutual Inductance.Reciprocity Theorem. Energystored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation andDisplacement current. **(5 L)**

Unit-V: Electrical Circuits: (15 marks)

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

Network theorems:

Ideal Constant-voltage and Constant-current Sources.Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.CDR. **(10 L)**

Recommended readings:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012,Tata McGraw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H.Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press

Expected learner outcome: This course will

1. Students will have a theoretical as well as practical knowledge about different electrical and magnetic properties of matter.
2. Develop the basic theoretical knowledge as well as experimental skills of the students on electrical networking.
3. Train the students to handle and repair instruments based on electric and magnetic field effects.

<u>Semester III</u>

Core-3

Paper Title: Mathematical Physics-I

Paper Code: PHYM 301 **Credit: 4**

Course Objectives: The course will enable the student to

1. To understand the importance of differential equation in physical science.
2. To learn different methods to solve ordinary and partial differential equation.
3. To acquire a clear understanding of linear differential equation and solution using special functions.
4. To understand the theory of errors and special integrals.

Unit I: Ordinary Differential Equations: (22 marks)

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(20 L)**

Unit II: Partial Differential Equation: (12 marks)

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical andspherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation. **(10 L)**

Unit III: Frobenius Method and Special Functions: (23 marks)

Singular Points of Second Order Linear Differential Equations and their importance.Frobenius method and its applications to differential equations.Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations.Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality. **(20 L)**

Unit IV:Some Special Integrals &Theory of Errors (13 marks)

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

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(10 L)

Recommended readings:

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

Expected learner outcome: This student will

1. gain complete analytical knowledge regarding differential equations.
2. Develop the basic theoretical knowledge to solve any kind of differential equation applied in physical situations.
3. be trained to use special integrals and error functions.

Core-4

Paper Name: Lab-I

Paper code: PHYM 302 **Credit 4**

Course Objectives: The course will enable the student to

1. Explore various experimental methods to analyze mechanical phenomena and material properties.
2. Utilize instruments and methodologies to measure physical quantities and verify scientific principles.
3. Study the characteristics of various electrical circuits to understand their behavior under different conditions.
4. Utilize measurement techniques to compare and analyze different electrical quantities such as electromotive forces and capacitances
5. Investigate the frequency response of electrical circuits to analyze their impedance characteristics and performance at different frequencies.
6. Verify theoretical principles such as Thevenin's theorem, Norton's theorem, and other fundamental laws of electrical circuits to understand their practical implications.

Group-A (Mechanics and properties of Matter)

1. Determination of g using bar pendulum.
2. Determination of g using Keter's pendulum.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel
5. To determine g and velocity for a freely falling body using Digital Timing Technique
6. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
7. To determine the Young's Modulus of a Wire by Optical Lever Method.
8. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
9. To determine the elastic Constants of a wire by Searle's method.
10. To determine the height of a building using a Sextant
11. To verify Jurin's law using Traveling Microscope.
12. Determine the Young's Modulus of a bar by uniform bending method.

Group-B (Electricity and Magnetism)

1. To study the characteristics of a series RC Circuit.
2. To compare two EMFs using the potentiometer.
3. Frequency response of a series LCR circuit.
4. Frequency response of a parallel LCR circuit.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To determine self-inductance of a coil by Anderson's bridge.
8. Determine a high resistance by leakage method using Ballistic Galvanometer (BG)
9. Determination of a Condenser using B.G
10. To determine an unknown Low Resistance using Carey Foster's Bridge.
11. To compare capacitances using De'Sauty's bridge.

Recommended Readings:

- Practical Physics. K.G Mazumdar & B.Ghosh, Shreedhar Publisher,Kolkata
- B.Sc Practical Physics C.L.Arora, S.Chand & Co.
- Practical Physics: Bhaskar Jyoti Hazarika, Ashoka Book Stall,Guwahati
- A textbook of Advanced Practical Physics Samir Kr Ghosh, Central Publisher

Expected Learner outcomes: The student will be skilled in

1. Explore experimental methods to determine g using different type of pendulums, the student shall perform experiments related to mechanics: Rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity) and fluid dynamics (Poiseulle's methd, Searle method, Jurin's law) etc, investigate spring motion, and utilize instruments like a sextant and a traveling microscope to measure building height and smaller distances etc.
2. Build up confidence in handling different types of electric circuits like RC,LCR etc, using DC/AC power sources, frequency generator, perform experiments using Anderson's bridge, De'Sauti's bridge, Carey-Foster's bridge, BG etc and also hand on learning on Netwok Theroems of electricity.

Semester IV

Core 5

Paper Title: Wave and Optics

Paper Code: PHYM 401 **Credit 4**

Course Objectives: The course will enable the student to:

1**.** Aware themselves about different phenomena's of wave and optics.

2. Apply basic knowledge of principles and theories about the behaviour of light and the physical environment to conduct experiments.

3. Explain several phenomena we can observe in everyday life that can be explained as wave phenomena.

4. Understand the principle of superposition of waves, so thus describe the formation of standing waves and also have an analytical knowledge about different types of wave motion.

5.To understand the phenomenon like interference, diffraction, polarization etc in both theoretical and practical aspect.

6. Understand the working of selected optical instruments like biprism, interferometer, diffraction grating, and holograms..

Unit I: Wave Motion: (marks 12)

Plane and Spherical Waves.Longitudinal and Transverse Waves.Plane Progressive (Travelling) Waves.Wave Equation.Particle and Wave Velocities.Differential Equation.Pressure of a Longitudinal Wave.Energy Transport.Intensity of Wave. Water Waves: Ripple and Gravity Waves. Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe.Newton's Formula for Velocity of Sound.Laplace's Correction. **(10 L)**

Unit II: Superposition of Collinear Harmonic oscillations: (marks 17)

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. LissajousFigures with equal an unequal frequency and their use.

Superposition of Two Harmonic Waves:

Standing (Stationary) Waves in a String: Fixed and Free Ends.Analytical Treatment.Phase and Group Velocities.Changes with respect to Position and Time.Energy of Vibrating String.Transfer of Energy.Normal

Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment.Longitudinal Standing Waves and Normal Modes.Open and Closed Pipes. Superposition of N Harmonic Waves. **(15 L)**

Unit III: Wave optics & Interference: (marks 16)

Electromagnetic nature of light, definition and properties of wave front.Huygens principle.Temporal and Spatial coherence

Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films:parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4)Refractive Index, and (5)Visibility of Fringes. Fabry Perot interferometer. **(15 L)**

Unit IV: Diffraction: (marks 25)

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only) Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope.Double slit. Multiple slits. Diffraction grating.Resolving power of grating.

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Holography:

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(20 L)**

Recommended readings:

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill.
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, AjoyGhatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Expected Learner outcomes: The student will be able to

1. Develop an understanding of various aspects of harmonic oscillations and waves specially.

(i) Superposition of collinear and perpendicular harmonic oscillations

(ii) Various types of mechanical waves and their superposition.

2. This course in basics of optics will enable the student to understand various optical phenomena, principles, workings and applications of optical instruments.

Core 6

Paper Title: Thermal Physics

Paper Code: PHYM 402 **Credit 4**

Introduction to Thermodynamics

Course Objectives: This course will enable a student to

1. Comprehend the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations.
2. Learn about Maxwell's thermodynamic relations.
3. Learn the basic aspects of kinetic theory of gases, Maxwell-Boltzman distribution law, equitation of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
4. Learn about the real gas equations, Van der Waal equation of state, the Joule Thompson effect.

Unit I:Zeroth and First Law of Thermodynamics: (**marks 10)**

Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. **(8 L)**

Unit II:Second Law of Thermodynamics: (marks 12)

Reversible and Irreversible process with examples.Conversion of Work into Heat and Heat into Work.Heat Engines.Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2 nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(10 L)**

Unit III: Entropy: (marks 10)

Concept of Entropy, Clausius Theorem.Clausius Inequality, Second Law of Thermodynamics in terms of Entropy.Entropy of a perfect gas.Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe.Entropy Changes in Reversible and Irreversible Processes.Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics.Unattainability of Absolute Zero. **(7 L)**

Unit IV:Thermodynamic Potentials: (marks 8)

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications.Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, ClausiusClapeyron Equation and Ehrenfest equations **(7 L)**

Unit V: Maxwell's Thermodynamic Relations: (marks 8)

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) ClausiusClapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process **(8 L)**

Unit VI: Kinetic Theory of Gases : (marks 12)

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 **(10 L)**

Unit VII: Real Gases (marks 10)

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. **(10 L)**

Recommended readings:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
- Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Expected Learner outcomes: A student will expected to gain some insights of basic thermal physics.

1. This basic course in thermodynamics will enable the student to understand various thermo dynamical concepts, principles.
2. Sound understanding of Kinetic theory of gases and transport phenomena based on this theory.
2. Basic understanding of how real gases behave after studying Andrew's and Joule-Thomson experiment etc.

Core 7

Paper title: Electronics-I

Paper Code: PHYM 403 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able

1. Describe number systems and Boolean algebra.
2. Know about the basic laboratory equipment of electronics.
3. Understand basic digital electronics concepts and digital circuits.
4. Explain the properties of intrinsic and extrinsic semiconductors.
5. Know about the basics of semiconductor PN junction, its various types and its application todifferent

electronic circuits.

6. Understand bipolar junction transistor and its applications as amplifier.

Section A: Introduction to Digital Electronics

Unit I: Digital Circuits: (marks 7)

Difference between Analog and Digital Circuits.Binary Numbers.Decimal to Binary and Binary to Decimal Conversion.BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(6 L)**

Unit II: Boolean algebra: (marks 8)

De Morgan's Theorems.Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products.Idea of Minterms and Maxterms.Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(7 L)**

Unit III: Data processing circuits: (marks 8)

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders.Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(7L)**

Section B: Introduction to Analog Electronics

Unit IV Semiconductor Diodes: (marks 12)

P and N type semiconductors. Energy Level Diagram.Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea).Barrier Formation in PN Junction Diode.Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(10L)**

Unit V:Two-terminal Devices and their Applications: (marks 6)

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(6 L)**

Unit VI:Bipolar Junction transistors: (marks 16)

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations.Current gains α and β Relations between α and β. Load Line analysis of Transistors.DC Load line and Q-point.Physical Mechanism of Current Flow.Active, Cutoff and Saturation Regions.Transistor Biasing and Stabilization Circuits.Fixed Bias and Voltage Divider Bias. **(14 L)**

Unit VII: Amplifiers: (marks 13)

Transistor as 2- port Network.h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains.Classification of Class A, B & C Amplifiers. **(10 L)**

Recommended readings:

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw Hill.
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman&S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan&N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

Expected Learner outcomes: This course will enable a student to

1. Identify and understand digital electronic principles and systems.
2. Apply the knowledge to analyze and apply digital circuits in solving circuit level problems.
3. Build real life applications using digital systems.
4. Learn the foundation knowledge of analog electronic systems.
5. Learn the working and applications of PN junction and bipolar junction transistors (BJT).
6. Learn to analyze circuits containing PN junction and BJT along with the application of BJTas amplifiers.

Core 8

Paper Title: Lab II

Paper Code: PHYM 404 **Credit 4**

Course Objectives: A student will be able to

1. Engage in experimental exploration of wave phenomena and optics.
2. Investigate various phenomena using hands-on experiments with different sources and setups.
3. Develop understanding of theoretical concepts and practical skills in analyzing optical properties and wave behavior.
4. Conduct experiments to explore heat transfer and thermal conductivity.
5. Gain practical insights into heat transfer mechanisms and material properties.
6. Explore electronic components and circuits through hands-on experiments and study their characteristics.
7. Study Bipolar Junction Transistors in different configurations and design amplifiers. Analyze frequency response of transistor amplifiers. Gain practical insights into electronic circuit design and behavior.

Group A: Wave and Optics

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2. To study Lissajous Figures.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
8. To determine dispersive power and resolving power of a plane diffraction grating.

Group B: Thermal Physics

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

Group C: Electronics-I

1. To test a Diode and Transistor using a Multimeter.
2. To design a switch (NOT gate) using a transistor.
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. To design a combinational logic system for a specified Truth Table.
5. Half Adder, Full Adder and 4-bit binary Adder.
6. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
7. To study V-I characteristics of PN junction diode, and Light emitting diode.
8. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
9. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
10. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
11. To study the various biasing configurations of BJT for normal class A operation.
12. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
13. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.

Recommended readings:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, KitabMahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, McGraw Hill.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
- Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

Expected Learner outcomes:

1. Experiment with wave phenomena and optics. Investigate using hands-on experiments with diverse sources and setups. Develop understanding of theoretical concepts and practical skills in optical analysis.
2. Explore heat transfer and conductivity through experiments. Determine heat equivalence and investigate thermal conductivity using various methods. Gain insights into material properties and heat transfer.
3. Conduct experiments to explore electronic components and circuits. Test diodes and transistors, design logic gates and amplifiers, and analyze characteristics such as voltage-current curves and frequency response. Gain practical insights into electronic circuit design.

Semester V

Core 9

Paper Name: Mathematical Physics-II

Paper Code: PHYM 501 **Credit: 4**

Course Objectives: A student will be able

1. To have an introduction to the theories of functions of complex variables, analytic function, contour integration and its application.
2. To calculate Fourier series and transformation of a function
3. To have understanding regarding different kind of integral transforms

4. To have deep understanding of Laplace transformation and its real life application

Unit I: Complex Analysis: (26 marks)

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region.Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **(24 L)**

Unit II: Fourier Series: (15 marks)

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only).Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. **(12 L)**

Unit III: Integrals Transforms: (14 marks)

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(12 L)**

Unit IV: Laplace Transforms: (15 marks)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. **(12 L)**

Recommended readings:

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

Expected Learner outcomes: This course will enable a student to

1. Enable analytical skill to solve different complex integration
2. Acquire different techniques for solving integral transformations
3. Application of Fourier and Laplace transformation in Physics

Core 10

Paper Name: Quantum Mechanics-I

Paper Code PHYM 502 **Credit: 4**

Course Objectives: Object of this course to enable a student to

1. To understand the principle of basic quantum mechanics with reference to classical mechanics.
2. To have a complete understanding of mathematical formulation of quantum mechanics.
3. To acquire analytical skill to solve Schrodinger equation and its application.
4. To have a basic idea of operator formulation.

Unit I: Introduction (23 marks)

Inadequacies of classical physics, Planck's quantum hypothesis , wave particle duality , photoelectric effect, Compton effect, de-Broglie hypothesis , phase and group velocity of de-Broglie waves, experimental verification of de-Broglie hypothesis (Davison Germer experiment), Bohr's complimentarily principle, Young's double slit experiment electron interference, Heisenberg's uncertainty principle, gamma ray microscope experiment to illustrate the uncertainty principle. Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle application to virtual particles and range of an interaction. **(20 L)**

Unit II: Wave equation: **(24 marks)**

Schrödinger's equation for a free particle and for a particle in a field, physical interpretation of the wave function, equation of continuity and probability current density, separation of Schrödinger's equation into space and time parts, time independent Schrödinger's equation, stationary states. Applications of Schrödinger's equation to simple problems: 1) free particle, 2) particle in a one-dimensional box with rigid walls, 3) step potential, calculation of transmission and reflection coefficients. **(20 L)**

Unit III: Operator formalism (introduction) (23 marks)

Operators in Quantum mechanics, linear, Hermitian and unitary operators, eigen values and eigen functions of an operator, orthonormality of eigen functions of a Hermitian operator, expectation values of an observable, Ehrenfest's theorem , Eigenvalues and Eigen functions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle **(20 L)**

Suggested readings:

- Quantum Mechanics P.M. Mathews and K. Venkateshan Tata McGraw Hill
- Quantum Mechanics A.K. Ghatak McMillan
- Quantum Mechanics V. Thankappan New Age International
- Principles of Quantum Mechanics S.P. Kuila New Central Book Agency P Ltd.
- Quantum Mechanics G. Aruldhas Prentice Hall of India
- Advanced Quantum Mechanics SatyaPrakash

Expected Learner outcomes: This course will enable a student to

1. Have a theoretical understanding of basics of quantum mechanics.
2. Use Schrodinger equation in different physical conditions.
3. Use operator theory properly.

Core 11

Paper Name: Classical Dynamics

Paper Code PHYM 503

Credit: 4

Course Objectives: At the completion of this course, a student will be able

1. To understand the mechanics of point particle with revision of Newtonian mechanics.
2. To understand Lagrangian and Hamiltonian formulation.
3. To know about small oscillation.
4. To appreciate special theory of relativity and its importance.
5. Study on Fluid dynamics.

Unit I: Classical Mechanics of Point Particles: (24 marks)

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

Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. **(20 L)**

Unit II: Small Amplitude Oscillations: (12 marks)

Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs. **(10 L)**

Unit III: Special Theory of Relativity: (22marks)

Postulates of Special Theory of Relativity.Lorentz Transformations.Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time -dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration.Metric and alternating tensors.Four-momentum and energy-momentum relation. Doppler effect from a four vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle. **(20 L)**

Unit IV: Fluid Dynamics: (12 marks)

Density and pressure in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number. **(10 L)**

Recommended readings:

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

- Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

Expected Learner outcomes: This course will enable a student to

1. Have a theoretical understanding of basics of classical mechanics.
2. Know about Lagrangian and Hamilotonian dynamics of a system.
3. Detailed knowledge about special theory of relativity.

Core 12

Paper Name: Lab-III

Paper Code PHYM 504 **Credit: 4**

Lab: Computational Physics

Course Objectives: At the completion of this course, a student will be able

1. Get an insight to computer hardware and computer applications.
2. Learn programming language from basic level such as C/Python
3. Familiarize with use of computer to solve Physics problems.
4. Familiarize with numerical computation software such as SCILAB/ MATLAB to solve complex problems related to Physics.

This course will consist of lectures (both theory and practical) in the Lab. Evaluation is to be done not on the programming but on the basis of formulating the problems.

- **Introduction to basics of programming language. (C, Python)**
- **Introduction to Numerical computation software SCILAB / MATLAB**
- **Theory of Errors: Types of errors, Normal Law, Standard and probable error, standard deviation, Variance etc.., Least-Square fit, Error on the slope and intercept of a fitted line.**
- **Solution of**
  - **Ordinary Differential Equation**
    - Radioactive decay
    - Current in RC, LC and DC sources
    - Newton's Law of cooling
    - Harmonic Oscillator (No friction)
    - Damped, Over damped, Critically damped Harmonic oscillator
    - LCR circuit response
  - **Partial Differential Equation**
    - Wave, Heat, Poisson', Laplace Equation
- **Solution of Quantum mechanical problems**
  1. Solve the s-wave Schrodinger equation for ground state and first excited state of hydrogen atom :

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

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

Here, m is the reduced mass of the electron. Obtain the energy eigen values and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = $0.511x10^6 eV/c^2$.

  2. Solve the s- wave radial Schrodinger equation for an atom

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

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

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

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 $(eVÅ)^{1/2}$, m = $0.511 \times 10^6 eV/c^2$, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

- **Solution of Statistical mechanical problems**

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lenard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   e) Computation and study of mean molecular speed and its dependence on particle mass
   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function Z(β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   a) Study of how Z(β), average energy < E >, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   b) Ratios of occupation numbers of various states for the systems considered above
   c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution

Recommended readings:

- Elementary Numerical Analysis, K.E.Atkinson, 3 r dE d n . 2 0 0 7, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
- Numerical methods: E. Balaguruswamy, Std. Edition, 2017, McGraw Hill
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Expected Learning Outcomes: This course will enable a student to

1. Use computer programme for solving Physics problems.
2. Prepare algorithms and flowcharts for Physics problem solving.
3. Learn computer coding to solve differential equations for physics problem solving.

Semester VI

Core 13

Paper Name: Statistical Mechanics

Paper code: PHYM601 **Credit 4**

Course Objectives: At the completion of this course, a student will be able

1. To understand different terms used in classical statistics with proper relation with thermodynamics.
2. To know about theory of classical and quantum description of radiation.
3. To analyze different classical and quantum statistics.

Unit I: Classical Statistics: (20 marks)

Macrostate& Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. **(18 L)**

Unit II: Classical Theory of Radiation: (11 marks)

Properties of Thermal Radiation.Blackbody Radiation.Pure temperature dependence.Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure.Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law.Ultraviolet Catastrophe. **(9 L)**

Unit III: Quantum Theory of Radiation: (7 marks)

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(5 L)**

Unit IV: Bose-Einstein Statistics: (15 marks)

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **(13 L)**

Unit V: Fermi-Dirac Statistics: (17 marks)

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **(15 L)**

Recommended readings:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

Expected Learning Outcomes: This course will enable a student to

1. Have an idea about classical statistics.
2. Get a clear understanding classical and quantum radiation.
3. Analyze quantum statistics and its applications in different fields.

Core 14

Paper Name: Solid State Physics

Paper Code PHYM 602 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able

1. To understand different crystal structure and basic lattice dynamics.
2. To have an idea about magnetic properties of matter.
3. To know about dielectric and ferroelectric properties of matter.
4. Understanding of band theory to distinguish among conductors, semiconductors and insulators.
5. To have a clear concept of superconductivity.

Unit I: Crystal Structure: (14 marks)

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements.Unit Cell.Miller Indices.Reciprocal Lattice.Types of Lattices.Brillouin Zones.Diffraction of X-rays by Crystals.Bragg's Law.Atomic and Geometrical Factor. **(12 L)**

Unit II: Elementary Lattice Dynamics: (12 marks)

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons.Qualitative Description of the Phonon Spectrum in Solids.Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(10 L)**

Unit III: Magnetic Properties of Matter: (10 marks)

Dia-, Para-, Ferri- and Ferromagnetic Materials.Classical Langevin Theory of dia– and Paramagnetic Domains.Quantum Mechanical Treatment of Paramagnetism.Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains.Discussion of B-H Curve.Hysteresis and Energy Loss. **(8 L)**

Unit IV: Dielectric Properties of Materials: (12 marks)

Polarization.Local Electric Field at an Atom. Depolarization Field.Electric Susceptibility.Polarizability.ClausiusMosotti Equation.Classical Theory of Electric Polarizability.Normal and Anomalous Dispersion.Cauchy and Sellmeir relations.Langevin-Debye equation.Complex Dielectric Constant.Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(8 L)**

Unit V: Ferroelectric Properties of Materials: (6 marks)

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(6 L)**

Unit VI: Elementary band theory: (10 marks)

Kronig Penny model.Band Gap.Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (four probe method) & Hall coefficient. **(10 L)**

Unit VII: Superconductivity: (6 marks)

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth.Isotope effect. Idea of BCS theory (No derivation) **(6 L)**

Recommended readings:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Expected Learning Outcomes: This course will enable a student to

1. Equip a student with basic concepts of solid state physics so that the knowledge can be applied for further development of the subject.
2. Get an overview of different crystal structures and the dynamics of crystal lattice
3. Get an idea of magnetic and dielectric properties of solids
4. Get basic knowledge on the band theory of solid and superconductivity in metals and alloys

Core 15

Paper Name: Nuclear and Particle Physics

Paper Code PHYM 603 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able

1. Get basic concepts of Nuclear Physics.
2. Understand the radioactive decay and nuclear reactions.
3. Get the idea and working principles of nuclear detectors
4. Emphasize on the existing connections with other domains of Physics, in particular Quantum, mathematical and particle physics

Unit I: General Properties of Nuclei: (12 marks)

Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity. **(10 L)**

Unit II: Nuclear Models: (12 marks)

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of nuclear force. **(10 L)**

Unit III: Radioactivity decay: (12 marks)

(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics. **(10 L)**

Unit IV: **Nuclear Reactions and Interaction of Nuclear Radiation with matter: (12 marks)**

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross Section. Energy loss due to ionization (Bethe-Block formula), Cerenkov radiation. photoelectric effect, Compton scattering. Gama ray interaction with matter, pair production **(10 L)**

Unit V:Nuclear Radiations detector and particle accelerator: (12 marks)

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(10 L)**

Unit VI: Particle Physics: (10 marks)

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. **(10 L)**

Recommended readings:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear Physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the Physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOPInstitute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

Expected Learning Outcomes: This course will enable a student to

1. Acquire knowledge of elementary and nuclear particles, as well as the characteristics and events that surround them.
2. Implement the same understanding to solve nuclear and particle physics problems.

Core 16

Paper Name: Lab IV

Paper Code PHYM 604 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able

1. Gain a comprehensive understanding of fundamental concepts in modern physics, through hands-on experimentation and theoretical analysis.
2. Gain expertise in experimental techniques to investigate diverse phenomena in modern physics, enabling the application of these skills to advance scientific understanding and address real-world challenges.
3. Gain a deep understanding of condensed matter physics principles through hands-on experiments.

4. Develop expertise in experimental techniques for characterizing material properties, advancing knowledge and technological applications in materials science.

Group A: Modern Physics

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Group B: Solid State Physics

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

Recommended readings:

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

Expected Learning Outcomes: This course will enable a student to

1. Proficiency in applying fundamental principles of modern physics to experimental investigations.
2. Competence in utilizing a variety of experimental techniques and instrumentation for data acquisition and analysis.

3. Ability to interpret experimental results critically and draw meaningful conclusions based on theoretical frameworks.
4. Effective communication of experimental findings through written reports and oral presentations, demonstrating understanding and relevance to real-world applications.

Semester VII

Core 17

Paper Name: Electro Magnetic Theory

Paper Code PHYM 701 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able to

1. Understand basic knowledge of Maxwell equations and their applications in various media.
2. Understand basic knowledge of polarization of EM wave.
3. Understand the basic knowledge of wave guide and its applications in optical fibers.

Unit I: Maxwell Equations: (15 marks)

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media.Wave Equations.Plane Waves in Dielectric Media.Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.Radiation from accelerated charge, radiation from electric dipole. **(14 L)**

Unit II: EM Wave Propagation in Unbounded Media: (12 marks)

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth.Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. **(10 L)**

Unit III: EM Wave in Bounded Media: (12 marks)

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) **(10 L)**

Unit IV: Polarization of Electromagnetic Waves: (13 marks)

Description of Linear, Circular and Elliptical Polarization.Propagation of E.M. Waves in Anisotropic Media.Symmetric Nature of Dielectric Tensor.Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction.Polarization by Double Refraction.Nicol Prism.Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light **(10 L)**

Unit V: Rotatory Polarization: (5 marks)

Optical Rotation.Biot's Laws for Rotatory Polarization.Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory.Specific rotation. Laurent's half-shade polarimeter. **(5 L)**

Unit VI: Wave Guides: (10 marks)

Planar optical wave guides. Planar dielectric wave guide.Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves , Field energy and power transmission. **(8 L)**

Unit VII: Optical Fibres: (3marks)

Numerical aperture , Step and Graded Indices (Definitions only), Single and Multimode fibres

(Concepts and Definition Only). **(3 L)**

Recommended readings:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
- Electromagnetic Fields & Waves, P.Lorrain&D.Corson, 1970, W.H.Freeman& Co.

Expected learner Outcomes: This course will enable a student to

1. Solve problems relevant to interfaces between media with defined boundary conditions.
2. Use Maxwell's equations to describe the behavior of electromagnetic waves in vacuum aswell as medium.
3. Describe states and methods of polarization and analyze the polarization state of a light source.

Core 18

Paper Name: Electronics-II

Paper Code PHYM 702 **Credit: 4**

Course Objectives: At the completion of this course, a student will be able:

7. Illustrate different types of sequential circuits.
8. Describe and design timing and counting circuits.
9. Explain memory organization of computing systems.
10. Describe internal mechanism and programming techniques of 8085 microprocessor.
11. Explain concepts of feedback in analog circuits.
12. Explain the working of OPAMPs and OPAMP based circuits.
13. Explain concepts of analog to digital conversion.

Section A: Digital Electronics

Unit I: Sequential Circuits: (8 marks)

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). **(6L)**

Unit II: Timers and Counters: (6 marks)

IC 555: block diagram and applications: Astable multivibrator and Monostablemultivibrator. Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(6L)**

Unit III:Computer Organization: (6 marks)

Input/Output Devices.Data storage (idea of RAM and ROM).Computer memory.Memory organization & addressing. Memory Interfacing. Memory Map. **(6 L)**

Unit IV: Intel 8085 Microprocessor Architecture: (16 marks)

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses.Registers.ALU.Memory. Stack memory. Timing & Control circuitry.Timing states.Instruction cycle, Timing diagram of MOV and MVI.Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instruction **(12 L)**

Section B: Analog Electronics

Unit IV: Feedback in Amplifiers: (8 marks)

Effect of positive and negative feedback on Input impedence, Output impedence, Gain , Stability, Distortion and noise. . Two stage RC coupled Amplifier and its frequency response. **(7L)**

Unit V: Sinusoidal Oscillators: (7 marks)

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley &Colpitts oscillators. **(7 L)**

Unit VI: Operational Amplifiers: (13 marks)

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

Applications of Op-Amps:

(1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. **(10L)**

Unit VII: Conversion: (3 marks)

Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) **(3 L)**

Unit VIII: Integrated Circuits (Qualitative treatment only): **(3 marks)**

Active & Passive components. Discrete components. Wafer.Chip.Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs.Examples of Linear and Digital ICs. **(3L)**

Recommended readings:

- Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics G K Kharate ,2010, Oxford University Press
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Expected Learning Outcomes: This course will enable a student to

1. Learn to analyze circuits containing BJT along with the application of BJT oscillators.
2. Develop basic knowledge of operational amplifier and its applications.
3. Study timer and counter circuits
4. Design and study analog to digital conversion techniques
5. Develop basic codes for 8085 microprocessor.

Core-19

Paper Name: Experimental Techniques

Paper Code: PHYM 703 **Credit 4**

Course Objectives: A student will be able:

1. To define discrete and continuous signals, time variant and invariant systems
2. To correlate experimental and theoretical knowledge.
3. To solve and find the output of a mentioned system for given inputs.
4. Describe the generalized instrumentation system and its different characteristics
5. Enhance the knowledge of measurement techniques and data and error analysis technique.
6. Categorize and compare different sensors and transducer and illustrate its applications.

Unit I: Measurements: (8 marks)

Accuracy and precision.Significant figures.Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting.Guassian distribution. **(7 L)**

Unit II: Signals and Systems: (8 marks)

Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise **(7 L)**

Unit III: Shielding and Grounding: (5 marks)

Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. **(4 L)**

Unit IV: Transducers & industrial instrumentation (working principle, efficiency, applications): (26marks)

Static and dynamic characteristics of measurement Systems.Generalized performance of systems, Zero order first order, second order and higher order systems.Electrical, Thermal and Mechanical systems.Calibration.Transducers and sensors.Characteristics of Transducers.Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. **(21 L)**

Unit V: Digital Multimeter: (5 marks)

Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(5 L)**

Unit VI: Impedance Bridges and Q-meter: (4 marks)

Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge. **(4 L)**

Unit VII: Vacuum Systems: (14 marks)

Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system Chamber Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization). **(12)**

Recommended readings:

- Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill

- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning

Expected learner outcome: This course will enable the students to

1. Develop and correlate the theoretical as well as experimental knowledge on different instruments and instrumentation.
2. Develop the knowledge of measurement techniques and data and error analysis technique.
3. Design and develop sensor based instrumentation system.
4. Handle different electrical network based instruments.

Core-20

Paper Name: Atomic and Molecular Physics

Paper Code: PHYM 801 **Credit 4**

Course Objectives: A student will be able to

1. Know about the development of modern Physics and the theoretical formulation of quantum mechanics.
2. Know the applications of quantum mechanics in solving physical problems.

Unit I: Quantum Theory of Atoms (17 marks)

Background of Quantum Theory: Bohr's model of the hydrogen atom, origin of spectral lines, Bohr's correspondence principle, Sommerfeld's atom model, designation of spectral term symbol. Vector atom model, space quantization, Larmor precession, the four quantum numbers, spectral terms arising from L-S coupling and j-j coupling, selection rules. **(15 L)**

Unit II: Fine structures of atoms (13 marks)

Fine structure of hydrogen spectra, doublet spectra of Na-atom Gyromagnetic ratio for orbital and spin motion, Lande's 'g' factor, strong and weak field effects, Zeeman Effect (normal and anomalous), Paschen Back and Stark Effect (Qualitative Discussion only).

(11 L)

Unit III: Molecular spectra and lasers (16 marks)

Molecular spectra: Pure rotation spectra, theory of pure rotation spectra, selection rules, vibration spectra and selection rules, theory of rotation-vibration spectra, P and R branches, Rayleigh and Raman scattering, Raman effect, classical theory of Raman effect Introduction to Lasers: Spontaneous and stimulated emission, population inversion, Einstein's A and B coefficients, qualitative ideas of Ammonia beam maser, ruby laser, He-Ne laser **(14 L)**

Unit IV: Atoms in Electric & Magnetic Fields: (12 marks)

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.. **(10 L)**

Unit V:Many electron atoms: (12 marks)

Pauli's Exclusion Principle. Symmetric &Antisymmetric Wave Functions.Periodic table.Fine structure. Spin orbit coupling. Spectral Notations for Atomic States.Total angular momentum.Vector Model.Spin-orbit coupling in atoms-L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali atoms (Na etc.) **(10 L)**

Suggested readings:

- Atomic Physics J.B. Rajam S. Chand and Company

- Fundamentals of Molecular Spectroscopy Banwell and McCash Tata McGraw Hill
- Molecular Structure and Spectroscopy G. Aruldhas Prentice Hall of India
- Atomic Spectra H.E. White McGraw Hill
- Modern Physics G. Aruldhas and P. Rajagopal Prentice Hall of India

Expected Learner Outcomes: This course will enable students to

1. Learn how to apply quantum mechanics to solve physical systems in different areas of science.
2. Know about the physical behavior of materials.
3. Learn how the scientific behavior of materials can be used for human applications.

Core-21

Paper Name: Quantum Mechanics II

Paper Code: PHYM 802 **Credit 4**

Course Objectives: At the completion of this course, a student will be able to

1. Understand the evolution of modern physics and the theoretical framework behind quantum mechanics.
2. Explore how quantum mechanics is utilized to address various physical challenges.
3. Explain how atoms interact with both electric and magnetic fields

Unit I: Time dependent Schrodinger equation: (24 marks)

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

(20 L)

Unit II: Time independent Schrodinger equation: (10 marks)

Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle. **(10 L)**

Unit III: General discussion of bound states in an arbitrary potential: (14 marks)

Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillatorenergylevels and energy eigen functions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. **(12 L)**

Unit IV: Quantum theory of hydrogen-like atoms: (22 marks)

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d... shells. **(18 L)**

Recommended readings:

- A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springe

Expected Learner Outcomes: This course will enable students to

1. Acquire proficiency in applying quantum mechanics to address diverse physical systems across various scientific disciplines.
2. Gain insight into the physical properties exhibited by materials.
3. Understand how the scientific properties of materials can be harnessed for practical human applications.

Core-22

Paper Name: Lab-V

Paper Code: PHYM 803 **Credit 4**

Course Objectives: At the end of this course the students will be able to

1. Experimentally verify fundamental laws and principles of electromagnetism.
2. Investigate the behavior of electromagnetic waves in different mediums.
3. Construct and analyze flip-flop circuits for sequential logic operations.
4. Develop skills in programming the 8085 microprocessor for arithmetic and control tasks.
5. Design and characterize analog circuits using operational amplifiers, transistors, and timers.
6. Study frequency response, oscillation, and amplification properties of electronic circuits.
7. Design and study sensor based systems for measurement of various physical parameters

Group A: EMT

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan`s law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Group B: Electronics II

1. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
2. To build JK Master-slave flip-flop using Flip-Flop ICs

3. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
4. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop,IC
5. To design an astable multivibrator of given specifications using 555 Timer.
6. To design a monostable multivibrator of given specifications using 555 Timer.
7. Write the following programs using 8085 Microprocessor
    a. Addition and subtraction of numbers using direct addressing mode
    b. Addition and subtraction of numbers using indirect addressing mode
    c. Multiplication by repeated addition.
    d. Division by repeated subtraction.
    e. Handling of 16-bit Numbers.
    f. Use of CALL and RETURN Instruction.
    g. Block data handling.
    h. Other programs (e.g. Parity Check, using interrupts, etc.).
8. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
9. To design a Wien bridge oscillator for given frequency using an op-amp.
10. To design a phase shift oscillator of given specifications using BJT.
11. To study the Colpitt`s oscillator.
12. To design a digital to analog converter (DAC) of given specifications.
13. To study the analog to digital convertor (ADC) IC.
14. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
15. To design inverting amplifier using Op-amp (741,351) and study its frequency response
16. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
17. To study the zero-crossing detector and comparator
18. To add two dc voltages using Op-amp in inverting and non-inverting mode
19. To design a precision Differential amplifier of given I/O specification using Op-amp.
20. To investigate the use of an op-amp as an Integrator.
21. To investigate the use of an op-amp as a Differentiator.
22. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

Group C: Experimental Techniques

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter.

Recommended readings:

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing
- House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted
- 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
- Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

Expected Learner Outcomes: This course will enable students to

1. Experimentally verify fundamental laws and principles of electromagnetism.
2. Experimentally verify different sequential circuits and familiarize with 8085 microprocessor programming
3. Design and study instrumentation systems and measure physical parameters for scientific purposes.