Darrang College (Autonomous), Tezpur-784001

Syllabus for

FYUGP

B.Sc. Physics (Major)

Approved by :

Board of Studies meeting held on 20-12-2025
&
Academic Council vide Resolution no. 2, dated 29-12-2025

FYUGP (Major) Syllabus

Subject: PHYSICS

(The syllabus is approved in the Board of Studies meeting held 20-12-2025)

Department of Physics

DARRANG COLLEGE (AUTONOMOUS)

TEZPUR

W.e.f. January 2026

The syllabus is subject to modifications as deem fit by the Academic Council, Darrang College (Autonomous)

AIMS OF FYUGP in PHYSICS

The FYUGP in Physics aims to cultivate not just knowledgeable physicists, but also well-rounded individuals who can contribute to society through their understanding of the physical world and their ability to solve problems creatively. The program mainly focuses on:

1. Solid Foundation in Physics:

To develop a strong base on the subject, the course includes mathematical Physics, mechanics, electricity &magnetism, thermodynamics, electronics, Electromagnetic Theory, classical mechanics, modern physics, statistical mechanics and quantum mechanics.

2. Experimental Skills:

Students learn, design, and conduct experiments in laboratories to demonstrate the concepts, principles, and theories learned in the classroom.

3. Problem-Solving Abilities:

The curriculum encourages students to develop strong and critical analytical and problem-solving skills, enabling them to tackle complex physics problems.

4. Interdisciplinary Learning:

Emphasize Physics as the most critical branch of science to pursue interdisciplinary and multidisciplinary higher education and research in interdisciplinary and multidisciplinary areas.

5. Practical Applications:

Students are encouraged to relate physics concepts to real-world applications and understand the relevance of physics in various fields, including advanced computing, sustainable energy, environmental management, and healthcare.

6. Preparation for Diverse Careers:

The program prepares students for careers in research, academia, industry, and other related fields.

PROGRAM OUTCOME

PO1: Knowledge Acquisition: Students will develop an adequate foundation of theoretical concepts and experimental techniques in physics.

PO2: Analytical and Problem-Solving Skills: Students graduating in Physics will be adept at critically analyzing physics problems, formulating solutions using mathematical and computational tools, and interpreting results.

PO3: Experimental Skills: Students will develop proficiency in conducting experiments, collecting and analyzing data, and drawing meaningful conclusions from observations.

PO4: Communication and presentation skills: Students will be able to communicate effectively about their understanding, ideas and findings to explain natural phenomena.

PO5: Digital and ICT efficiency: Students will be able to use modern ICT tools in a variety of learning environments for knowledge gain, and work places to broaden the capability and improve efficiency.

PO6: Teamwork and leadership: Students will be able to develop teamwork and leadership abilities to work effectively in a co-operative and coordinated manner within diverse teams and peer groups.

PO7: Iinterdisciplinary Awareness: Students will understand how physics principles relate to other scientific disciplines and how interdisciplinary knowledge can contribute to problem-solving.

PO8: Ethics and Values: Students will comply with ethical conduct and adhere to professional standards in learning.

PO9: Employability and entrepreneurial skills: Students will acquire adequate skills and knowledge to become employable.

TEACHING LEARNING PROCESS

The method and practice of teaching for FYUGP in Physics is based on the L+T+P model, where L, T, and P stand for Lecture, Tutorial, and Practical respectively. Lecture classes are aided with prescribed textbooks, e-learning resources, and self-study materials. This approach recognizes the importance of a well-rounded education that includes theoretical knowledge, practical experience, and personal development. Tutorials are interactive sessions where students can ask questions, clarify their doubts, and engage in discussions with their peers and teachers. Tutorials are designed to encourage active learning and to promote critical thinking. The practical courses are designed to provide hands-on experience to students and to help them develop the necessary skills for conducting experiments and record results. The following methods are used in teaching learning process

- Classroom lectures
- Practical demonstration
- Group discussion

Teaching Learning Tools:

- Textbook, hand notes
- Blackboard/ Whiteboard
- ICT tools (Powerpoint presentation, e-learning platform)

EVALUATION/ASSESSMENT

<table>
<tr><th rowspan="2">Paper</th><th colspan="3">In-semester</th><th colspan="3">End-Semester</th><th rowspan="2">Grand Total Marks</th></tr>
<tr><th>Activity</th><th>Marks</th><th>Total</th><th>Activity</th><th>Marks</th><th>Total</th></tr>
<tr><td></td><td colspan="3">For courses with practical</td><td rowspan="2">Theory Examination</td><td rowspan="2">45</td><td rowspan="3">70</td><td rowspan="3">100</td></tr>
<tr><td rowspan="4">Major/Minor</td><td>Sessional Examination</td><td>15</td><td rowspan="2">30</td></tr>
<tr><td>Seminar/presentation, assignment, regularity, classroom activity etc.</td><td>15</td><td>Practical Examination</td><td>25</td></tr>
<tr><td colspan="3">For courses with no practical</td><td rowspan="2">Theory</td><td rowspan="2">60</td><td rowspan="2">60</td><td rowspan="2">100</td></tr>
<tr><td colspan="2">Sessional+ Assignment/presentation, attendance etc</td><td>40</td></tr>
<tr><td rowspan="2">SEC</td><td>Sessional Examination</td><td>15</td><td rowspan="2">30</td><td rowspan="2">Theory Examination</td><td rowspan="2">45</td><td rowspan="2">45</td><td rowspan="2">75</td></tr>
<tr><td>Seminar/presentation, assignment, regularity, classroom activity etc.</td><td>15</td></tr>
</table>

1 Credit= 1 hour of Lecture/ 1 hour of Tutorial

1 Credit= 2 hours of Practical class

COURSE STRUCTURE

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
I	Major	Mathematical Physics-I and Mechanics	PHY-MJ-01014	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	SEC	Renewable Energy and Energy Harvesting	PHY-SEC-01013	**Theory**	**3**	**45**	**30**			**75**
	Minor	**--**	--	**--**	**4**					

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
II	Major	Electricity and Magnetism	PHY-MJ-02014	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	SEC	Basic Skills in Electronics	PHY-SEC-02013	**Theory + Practical**	**3**	**15**	**10**	**40**	**10**	**75**
	Minor				**4**					

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
III	Major	Mathematical Physics-II	PHY-MJ-03014	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Wave and Oscillations	PHY-MJ-03024	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	SEC	Data Processing and Analysis	PHY-SEC-03013	**Theory + Practical**	**1+2**	**15**	**10**	**40**	**10**	**75**
	Minor				**4**					

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
IV	Major	Mathematical Physics-III and Special Theory of Relativity	PHY-MJ-04014	**Theory**	**4**	**60**	**40**	**0**	**0**	**100**
	Major	Optics	PHY-MJ-04024	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Thermal Physics	PHY-MJ-04034	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Quantum Mechanics I	PHY-MJ-04044	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Minor				**4**					

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
V	Major	Electromagnetic Theory	PHY-MJ-05014	**Theory + practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Atomic and Nuclear Physics	PHY-MJ-05024	**Theory**	**4**	**60**	**40**			**100**
	Major	Analog and Digital	PHY-MJ-05034	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Minor			**4**						
	Internship									

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	Th IA	PR	PR IA	
VI	Major	Condensed Matter Physics	PHY-MJ-06014	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Statistical Mechanics	PHY-MJ-06024	**Theory + practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Classical Mechanics & Astrophysics	PHY-MJ-06034	**Theory**	**4**	**60**	**40**			**100**
	Major	Minor Project & IKS in Astronomy	PHY-MJ-06044	**Theory + Practical**	**3+1**	**60**	**40**			**100**
	Minor			**4**						

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	**Th IA**	**PR**	**PR IA**	
VII	Major	Advanced Mathematical Physics	PHY-MJ-07014	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Atomic, Molecular and Laser Physics	PHY-MJ-07024	**Theory + Practical**	**3+1**	**45**	**30**	**20**	**05**	**100**
	Major	Classical Mechanics-II	PHY-MJ-07034	**Theory**	**4**	**60**	**40**			**100**
	Major	Nuclear and Particle Physics-II	PHY-MJ-07044	**Theory**	**4**	**60**	**40**			**100**
	Minor	Research Methodology			**4**					

Sem	Type	Course	Code	Course Type	Credit	Marks Distribution				Total
						Th	**Th IA**	**PR**	**PR IA**	
VIII	Major	Quantum Mechanics-II	PHY-MJ-08014	**Theory**	**4**	**60**	**40**	**0**	**0**	**100**
	Major	Advanced Condensed Matter Physics	PHY-MJ-08024	**Theory**	**4**	**60**	**40**	**0**	**0**	**100**
	Major	Electromagnetic Theory-II	PHY-MJ-08024	**Theory**	**4**	**60**	**40**	**0**	**0**	**100**
	Major	Research Project/Dissertation	PHY-MJ-08044	**Practical**	**4**			**80**	**20**	**100**
	Minor				**4**					

Th = Theory

Th IA = Theory Internal Assessment

Pr = Practical

Pr IA = Practical Internal Assessment

Subject: Physics (Major)
Semester: First
Course Name: Mathematical Physics I and Mechanics
Paper Code: PHY-MJ-01014
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

This course introduces mathematical physics and mechanics. The basic objectives of the course are:

- To introduce essential primary concepts in mathematical physics such as vectors and scalar fields, vector products, calculus of vectors, differential operators which are required for developing insight of the theories of physics.
- To introduce basic concepts of matrix algebra.
- To introduce the concepts of dynamics of particles, energy, oscillation and basic properties of matter which will equip students with the tools required for applying the concepts of physics in practical problems.
- To train the students with concept visualisation through some laboratory practices.

Course Outcome:

On successful completion of the course, students will be able to understand the calculus of vectors and different operators which will be helpful in understanding theories of physics. Through matrix algebra students will be able to compute various matrix operations which are required for solving physical problems. Students will be able to understand and apply the concepts of dynamics of particles, simple harmonic oscillations, basic properties of matter in various problems of physics, technology and engineering. They will be trained in concept realisation through laboratory practices.

Title of the course	Mathematical Physics I and Mechanics
Course code	PHY-MJ-01014
Total Credit	4 (3 Theory+ 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment: 30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
Part A: Mathematical Physics I				30	75
I	Vector and scalars	2	0		
II	Vector differentiation	3			
III	Vector differential operator	5			
IV	Vector Integration	3			
V	Matrices	2			
Part B: Mechanics					
I	Reference frames	3	0		
II	Central force motion	5			
III	Conservation laws	4			
IV	Dynamics of rigid bodies	6			
V	Work and energy	4			
VI	Properties of matter	6			
VII	Oscillations	2			

DETAILED SYLLABUS

Mathematical Physics I and Mechanics

Theory (Credit 3)

Part A: Mathematical Physics I

Unit I: Vector and scalars **Lectures: 2**

Scalar and vector fields, dot and cross products including triple products, their physical significance.

Unit II: Vector differentiation **Lectures 3**

Ordinary derivative of vectors. Continuity and differentiability, the partial derivative of vectors, applications to problems in Physics.

Unit III: Vector differential operator **Lectures 5**

Gradient. Divergence and curl - definitions and physical meaning.

Unit IV: Vector Integration **Lectures 3**

Ordinary integrals of vectors - line integral, surface integral and volume integral. Gauss's theorem, Stoke's theorem and Green's theorem (statements only).

Unit V: Matrices **Lectures 2**

Review of basic concepts. Types of matrices: Hermitian, anti - Hermitian, Unitary, orthogonal, symmetric and skew-symmetric. Diagonalisation of matrices, inverse of a matix, Eigen values and Eigen vectors, Caley -Hamilton theorem (statement only).

Part B: Mechanics

Unit I: Reference frames **Lectures 3**

Inertial and non- inertial frames of reference, e.g., rotating frames, laws of Physics in rotating coordinate system. Fictitious forces: Coriolis force and its application, centrifugal force.

Unit II: Central force motion **Lectures 5**

Motion under central force. Two-body problem and its reduction to one body problem. Kepler's laws of planetary motion, Gravitational Law and Field, Conservative and Non-conservative forces.

Unit III: Conservation laws **Lectures 4**

Dynamics of a system of particles. Centre of mass. Principle of conservation of momentum. Torque. Impulse. Elastic and inelastic collisions between particles. Centre of mass and laboratory frames.

Unit IV: Dynamics of rigid bodies **Lectures 6**

Translation and rotational motion, torque, angular momentum. Moment of inertia -general theorem of the moment of inertia, moment of inertia calculation in particular cases - disk, cylinder, and sphere. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit V: Work and energy **Lectures 4**

Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Force as gradient of potential energy. Work done by non- conservative forces.

Unit VI: Properties of matter **Lectures 6**

Elasticity: Hook's law, elastic constants, Poisson's ratio, relation among the elastic constants. Twisting torque on a cylinder or wire. Bending of beam: Bending moment, cantilever, depression of a cantilever considering the weight of the beam. Fluid dynamics: Equation of continuity, types of flow, viscosity, Poiseuille's equation for flow of a liquid through a capillary tube.

Unit VII: Oscillations **Lectures 2**

Simple Harmonic Motion, Characteristics of SHM, Differential equation of SHM, Energy of SHO, Types of SHM – free, damped and forced oscillations (qualitative only), Compound Pendulum.

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following:

1. To study the motion of spring and calculate (a) spring constant and (b) rigidity modulus.
2. To determine the moment of inertia of a cylinder about two different axes of symmetry by torsional oscillation method.
3. To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method).
4. To determine the Young's modulus of the material of a wire by Searle's apparatus.
5. To determine the modulus of rigidity of a wire (static method).
6. To determine the value of g using bar pendulum.
7. To determine the value of g using Kater's pendulum.
8. To determine the height of a building using a sextant.
9. To determine g and velocity for a freely falling body using digital timing technique.

Suggested Readings:

- Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
- Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).
- Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
- Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
- Mechanics; D. S. Mathur, S. Chand & Company Limited.
- An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et. al., Tata McGraw-Hill.
- Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.
- Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
- B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
- A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

Course designed by:

i. Dr. Saiful Islam, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

ii. Dr. Shyamalima Chowdhury, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

iii. Dr. Barsha Borgohain, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

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Subject: Physics (Major)
Semester: Second
Course Title: Electricity and Magnetism
Course Code: PHY-MJ-02014
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To provide foundational knowledge of electrostatics, magnetostatics, and current electricity.
- To introduce fundamental laws, field concepts, and circuit analysis methods.
- To develop students' ability to apply theoretical principles to practical scenarios.
- To familiarize students with electric and magnetic properties of matter.
- To build competence through laboratory exercises using measurement and analytical tools.

Course Outcome:

On successful completion, students will be able to

- Analyze and solve problems in electrostatics and magnetostatics using core laws and principles.
- Apply circuit theorems and explain the properties of dielectrics and magnetic materials.
- Interpret interactions between electric and magnetic fields in physical systems.
- Perform laboratory measurements and verify experimental principles.
- Use basic electrical instrumentation effectively in practical tasks.

Title of the course	Electricity and Magnetism
Course code	PHY-MJ-02014
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment: 30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Electric field	3	0	30	75
II	Electric Potential	6			
III	Work and Energy in Electrostatics	2			
IV	Dielectric properties of matter	4			
V	Electric Current	4			
VI	Circuit Theorem	3			
VII	Transient Current	3			
VIII	Alternating Current	5			
IX	Magnetic Field	4			
X	Divergence and Curl Magnetic Field	4			
XI	Magnetic potential	2			
XII	Magnetic properties of matter	5			

DETAILED SYLLABUS

Electricity and Magnetism

Theory (Credit 3)

Unit I: Electric field **Lectures 3**

Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and cylindrical symmetries. Conservative nature of electrostatic field.

Unit II: Electric Potential **Lectures 6**

Electrostatic potential. Laplace's and Poisson's equations. Electrostatic boundary conditions. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Parallel plate capacitor.

Unit III: Work and Energy in Electrostatics **Lectures 2**

Work done in moving a point charge, Electrostatic energy of a system of charges. Electrostatic energy of continuous charge distribution

Unit IV: Dielectric properties of matter **Lectures 4**

Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector D. Relation between E, P and D. Gauss's law in dielectrics.

Unit V: Electric Current **Lectures 4**

Electric current density, continuity equation, Ohm's law, Applications of Kirchoff's law to solve electrical network problem,

Unit VI: Circuit Theorem **Lectures 3**

Thevenin and Norton Theorems. Superposition theorem, maximum power transfer theorems.

Unit VII: Transient Current
Lectures 3

Transient growth and decay of current in LR, CR and LCR circuits, oscillatory discharge

Unit VIII: Alternating Current **Lectures 5**

Phasor (complex number method) method of analyzing a.c. circuits, current and potential across resistive, inductive and capacitive elements and their phase relationships, power factor, LR, CR and LCR (series and parallel) circuits, quality factor, resonance, Anderson's bridge.

Unit IX: Magnetic Field **Lectures 4**

Magnetic field definition and properties, Magnetic force on a point charge, Lorentz force.

Biot-Savart law, Magnetic field due to a steady current in (a) straight conductor and (b) a circular coil.

Unit X: Divergence and Curl Magnetic Field **Lectures 4**

Divergence and Curl of a magnetic field. Ampere's circuital law and it's application to its application to (i) long straight conductor, (ii) solenoid and (iii) torus.

Unit XI: Magnetic potential **Lectures 2**

Magnetic vector potential, Magnetostatic boundary conditions.

Unit XII: Magnetic properties of matter **Lectures 5**

Force and torque on a current loop in a uniform magnetic field, Current loop as a magnetic dipole. Magnetization vector $\vec{M}$, Magnetic intensity $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism, B-H curve and hysteresis (basics only).

Practical (Credit 1, Contact hours 30)

(Minimum six experiments must be performed from the following)

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton Theorems.
8. To verify the superposition
9. To verify maximum power transfer theorems.
10. To determine the self-inductance of a coil by Anderson's bridge.
11. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
12. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Suggested Readings:

- Introduction to Electrodynamics, D. J. Griffiths. Prentice Hall Inc., 2013, New Jersey
- Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.
- Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata Mcgraw.
- Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
- Electromagnetics, B. B. Laud, New Age International Publishers.
- Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
- Elements of Electromagnetics, M. N. O. Sadiku, 2008. Pearson Education.
- Electricity and Magnetism, J. W. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press.

Course designed by-

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- Prof. Arup Kr. Deka, Department of Physics, Darrang College (Autonomous), Tezpur, Assam.
- Dr. Dibya Jyoti Sivananda, Department of Physics, Darrang College (Autonomous), Tezpur, Assam.

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Subject: Physics (Major)
Semester: Three
Course Name: Mathematical Physics - II
Course Code: PHY-MJ-03014
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

The basic objectives of the course are —

- To introduce the concept of curvilinear coordinates and
- To introduce the methods of solving differential equationsusing various methods.
- To understand complex analysis principles, including analytic functions, complex integration and residue theorem.
- To introduce Gamma and Dirac delta function.

Course Outcome:

On successful completion of the course, students will be able to understand introduce the concept of curvilinear coordinate system and their applications in real world problems. They will be able to solve differential equations . Also they will understand complex analysis principles, including analytic functions, complex integration using residue theorem. They will learn apply Gamma and Dirac delta function in various branches of physical problems.

Title of the course	Mathematical Physics-II
Course Code	PHY-MJ-01014
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45 (L) + 0 (T) + 30 (P)
Distribution ofMarks	InternalAssessment:30 End Semester Examination: Theory = 45, Practical = 25

Course Summary:

Unit	Topic	Lectures (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Curvilinear coordinates	10	0	30	75
II	Differential equations	15			
III	Complex Analysis	10			
IV	Fourier Series	6			
V	Gamma and Dirac Delta Function	4			

DETAILED SYLLABUS

Mathematical Physics-II

Theory (Credit 3)

Unit I: Curvilinear coordinates **Lectures 10**

Introduction to curvilinear coordinates. Orthogonal curvilinear coordinates. Examples of spherical, cylindrical and plane polar coordinates. Line element- transformation from Cartesian to curvilinear coordinates (spherical and cylindrical). Gradient, divergence and curl in spherical and cylindrical coordinates.

Unit II: Differential equations **Lectures 15**

First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients - complementary function and particular integral (physical examplessimple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence of 2nd order homogeneous linear differential equation.Partial differential equations (PDE) (physical examples – wave equation, diffusion equation, Laplace and Poisson equation – introduction only). Exact and inexact differentials. Concept of variable separation in a PDE.

Unit III: Complex Analysis **Lectures 10**

Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Complex Integration: Integration of a function of a complex variable. Cauchys Integral formula. Simply and multiply connected region. Laurent and Taylors expansion. Residues and Residue Theorem. Evaluation of complex integrals using residue Theorem (Applications of residue theorem).

Unit IV: Fourier Series **Lectures 6**

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. Applications; square wave, triangular waves, etc

Unit V: Gamma and Dirac Delta Function **Lectures 4**

Definition and properties of Gamma function and Dirac Delta Function.

Practical (Credit 1, Contact Hours 30)

(At least five experiments to be performed from the following)

1. Solve differential equations
   $\frac{dy}{dx} = e^x$ with y=0 for x=0
   $\frac{dy}{dx} + e^{-x} y = x^2$
   $\frac{d^2 y}{dt^2} + 2\frac{dy}{dt} = -y$
   $\frac{d^2 y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$
2. Dirac Delta function: Evaluate the integral I
   $I = \frac{1}{\sqrt{2\pi\sigma^2}}\int \exp\left[-\frac{(x-2)^2}{2\sigma^2}\right](x+3)dx$ for σ =1.0, 0.1, 0.01 and show that $I \to 5$
3. Fourier Series
   Make a program to evaluate

   $\sum_{n=1}^{\infty}(0.2)^n$, Evaluate the Fourier coefficients of a given periodic function (square wave).
4. Calculation of least square fitting manually without giving weightage to error.
   Confirmation of least square fitting of data through computer program.
5. Integrate

   $\frac{1}{(x^2+2)}$
   numerically from x=1 to 2..
6. Compute the n^{th} roots of unity for n=2, 3, and 4.
7. Find two square roots of 5+12*j*

Suggested Readings:

- Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
- Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
- Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York).
- Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
- Mathematical Physics; H K Dass and R Verma, S Chand and Company limited.
- Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
- Complex Variables; M R Spiegel, S Lipschutz, J J Schiller and D Spellman, Schaum's Outline Series, McGraw Hill Education.

- Ordinary and Partial Differential equations; M. D Raisinghania, S. Chand and Company Ltd.
- Complex variables Demystified (A self-teaching guide); D McMahan, McGraw Hill Education.

<u>Course designed by</u> **–**

i) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous), Tezpur, Assam.

ii) Dr. Archana Haloi, Department of Physics, Darrang College (Autonomous), Tezpur, Assam.

iii) Prof. Manoj Kr. Sarma, Department of Physics, Darrang College (Autonomous), Tezpur, Assam.

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Subject: Physics (Major)

Semester: Three
Course Name: Waves and Oscillations
Course Code: PHY-MJ-03024
Credit: 4 (3 Theory + 1 Practical)

Course Objective:

This course is aimed to provide in depth knowledge of waves and oscillations and their applications in physical world.

Course Outcome:

After successful completion the student will gain knowledge about SHM, combination of SHM, formation of standing waves and velocity of waves in media, Acoustics of halls, reverberation and will get hands on experience of operating CRO and other practical apparatus.

Title of the course	Waves and Oscillations
Course code	PHY-MJ-03024
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Oscillations	4	0	30	75
II	Superposition of Harmonic Oscillations	6			
III	Damped and forced Oscillations	8			
IV	Waves	6			
V	Velocity of waves	6			
VI	Superposition of two harmonic waves	9			
VII	Sound	6			

DETAILED SYLLABUS

Waves and Oscillations

<u>Theory (Credit 3)</u>

Unit I: Oscillations Lectures 4

Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Anharmonic or nonlinear oscillation.

Unit II: Superposition of harmonic oscillations Lectures 6

Linearity and Superposition principle, Superposition of two collinear oscillations having (i) equal frequencies and (ii) different frequencies (Beats), Lissajous figures and their use. Fourier series and Fourier coefficients, Fourier analysis in some simple cases (square and saw tooth wave).

Unit III: Damped and forced Oscillations Lectures 8

Damped oscillation, critical, damping, logarithmic decrement, energy of a damped harmonic oscillator, power dissipation, Q-factor of an oscillator, forced vibration, amplitude and velocity resonance, Sharpness of resonance.

Unit IV: Waves Lectures 6

Progressive Waves, wave equation, plane wave and spherical wave, Longitudinal and Transverse Waves, dispersion, group velocity, phase velocity, energy density and intensity of waves.

Unit V: Velocity of waves Lectures 6

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

Unit VI: Superposition of two harmonic waves Lectures 9

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

Unit VII: Sound Lectures 6

Intensity and loudness of sound, ultrasonic wave, production of ultrasonics, piezo electric generator. Acoustics of halls, reverberation and Sabines formula.

<u>Practical (Credit 1, Contact Hours 30)</u>

(At least five experiments to be performed from the following)

1. To study damping effect of simple harmonic motion using bar pendulum.
2. To determine torsional rigidity of a wire.
3. To determine the frequency of AC main by sonometer using non magnetic wire.
4. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2-T law
5. Study of Lissajous figure of two different waves using CRO and find out the unknown frequency of an electrical signal.

<u>Suggested Readings:</u>

1. Vibration, Waves and Acoustics, D.Chattopadhyay, 2010, New Central Book Agency
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
3. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
4. A Textbook of Sound, 3rd Edition, A. B. Wood, 1955, Bell & Sons
5. Vibrations and Waves in Physics, 2nd edition, I. G. Main, 1984, Cambridge University Press.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Geeta Sanon, BSc Practical Physics, 1st Edn. 2007, R. Chand & Co.
8. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
9. B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
10. A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

<u>Course designed by</u>

i) Dr. Shyamalima Chowdhury, Department of Physics, Darrang College(Autonomous) Tezpur, Assam.

ii) Dr. Barsha Borgohain, Department of Physics, Darrang College(Autonomous) Tezpur, Assam.

iii) Prof. Arup Kr. Deka, Department of Physics, Darrang College(Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Four

Course Name: Mathematical Physics – III and Special Theory of Relativity
Course Code: PHY-MJ-04014
Credit: 4 (Theory)

Course Objectives:

The basic objectives of the course are —

- To solve partial differential equations using various methods.
- To develop proficiency in tensor algebra, covering transformations, contravariant and covariant tensors and tensor algebra.
- To gain a preliminary knowledge to probability theory. Mean and variance calculations.
- To gain knowledge about relativistic mechanics.
- To gain preliminary knowledge about four vector and Minkowski Space

Course Outcome:

On successful completion of the course students will able to solve partial differential equations, understand properties of Tensor like Transformation of coordinates, contravariant and co-variant tensors, indices rules for combining tensors. They will understand the basic concepts of relativity and Lorentz transformations. They will also gain an idea about how mechanics is modified in relativistic domain.

Title of the course	Mathematical Physics-III and Special Theory of Relativity
Course code	PHY-MJ-04014
Total Credit	4 (Theory)
Contact hours	50(L) + 10(T) + 0(P)
Distribution of Marks	Internal Assessment:40 End Semester Examination: Theory=60

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Partial Differential Equations	12	10	0	60
II	Tensor Algebra	10			
III	Introduction to Probability	6			
IV	Special Theory of Relativity	14			
V	Four Vector Relativity	8			

DETAILED SYLLABUS
Mathematical Physics-III and Special Theory of Relativity

Theory (Credit 3)

Unit I: Partial Differential Equations **Lectures 12**

Introduction to PDE, linear and non-linear PDE, homogeneous and non-homogeneous PDE, Order of PDE, Solutions to partial differential equations, using separation of variables: Wave equation and its solution for vibrational modes of a stretched string.

Unit II: Tensor Algebra **Lectures 10**

Introduction to tensor, Transformation of co-ordinates, Einsteins summation convention. contravariant and co- variant tensor, tensorial character of physical quantities, symmetric and antisymmetric tensors, Kronecker delta, Levi-Civita tensor. Quotient law of tensors, Raising and lowering of indices Rules for combination of tensors- addition, subtraction, outer multiplication, contraction and inner multiplications.

Unit III: Introduction to Probability **Lectures 6**

Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance calculations.

Unit IV: Special Theory of Relativity **Lectures 14**

Review of Galilean transformation and its inadequacy. Michelson Morley experiment Postulates of Special Theory of relativity. Lorentz transformation. Length contraction and time dilation. Simultaneity and order of events. Relativistic addition of velocities. Variation of mass with velocity. Mass-energy relation. Examples of mass energy conversion. Relation between momentum and energy and conservation laws. Transformation of momentum and energy. Particles with zero rest mass energy. Force in relativistic mechanics. Loretz transformation of force.

Unit V: Four Vector Relativity **Lectures 8**

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: spacelike, time-like and light-like. Four-velocity and acceleration.

Suggested Readings:

- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, and F. E.. Harris, 2013, 7th Edn., Elsevier.
- An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI
- Learning Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical Physics, Goswami, 1st edition, Cengage Learning
- Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press
- Classical Mechanics, J. C. Upadhaya
- Classical Mechanics, P.S. Joag and N.C Rana (McGraw Hill Book Company) Mechanics, D.S. Mathur

Course designed by –

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ii) Dr. Archana Haloi, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
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Subject: Physics (Major)
Semester: Four

Course Name: Optics
Course Code: PHY-MJ-04024
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

The present course offers an all-encompassing survey of the basic principles of optics and Laser, building upon the fundamental knowledge gained in previous educational endeavors. Furthermore, the present course explores the creation of innovative ideas within this particular area of study.

Course Outcome:

At the end of the course the following concepts will be clear to the students

- The origin of ray optics and its applications
- Understand Interference as superposition of waves from coherent sources derived from same parent source
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction
- Understand polarization of light
- Fundamental principles of lasing mechanism and identifying various types of lasers
- Basics of Holography and its applications

Title of the course	Optics
Course Code	PHY-MJ-04024
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Ray Optics	7	0	30	75
II	Defects of Image	7			
III	Introduction to Wave Optics	3			
IV	Interference	8			
V	Diffraction	8			
VI	Polarization	5			
VII	Lasers	4			
VIII	Holography	3			

DETAILED SYLLABUS
Optics

Theory (Credit 3)

Unit 1: Ray Optics **Lectures 7**

Fermat's principle and its application in establishing laws of reflection and refraction at spherical and plane boundaries, Sign convention, conjugate foci, relation for refraction of paraxial rays at single spherical surface, interrelation among lateral, longitudinal and angular magnification, Lagrange's law and Helmholtz equation and its modification for telescopic system.

Unit 2: Defects of Image **Lectures 7**

Spherical aberration and its magnitude for thin lens for object at finite distance and condition for minimum aberration when object is at infinity, Minimization of spherical aberration by using suitable lens of different radii of curvature and by aplanatic surface, Qualitative idea about coma, astigmatism and distortion, Chromatic aberration, circle of least confusion, achromatism of two thin lenses separated by a distance.

Unit 3: Introduction to Wave Optics **Lectures 3**

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

Unit 4: Interference **Lectures 8**

Superposition principle, Intensity distribution in an interference pattern, Division of wave front and amplitude, Young's double slit experiment, Fresnel's Biprism. Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films, Newton's Rings: Measurement of wavelength and refractive index, Michelson interferometer.

Unit 5: Diffraction **Lectures 8**

Fresnel and Fraunhofer diffraction, Fresnel's Half-Period Zones for Plane Wave, Fresnel diffraction pattern of a straight edge and at a circular aperture, Fraunhofer diffraction: Single slit and Double slit, Diffraction grating, Resolving power of grating.

Unit 6: Polarization **Lectures 8**

Polarized light and its mathematical representation, Production of polarized light by reflection, refraction and scattering, Polarization by double refraction and Huygen's theory, Calcite Crystal and Optic axis, Polarizer: Nicol prism, Retarding Plates, Production and analysis of circularly and elliptically polarized light.

Unit 7: Lasers **Lectures 4**

Einstein's A and B coefficients, Metastable states, Spontaneous and Stimulated emissions, Optical Pumping and Population Inversion, Three-Level and Four-Level Lasers, Ruby Laser and He-Ne Laser.

Unit 8: Holography **Lectures 3**

Principle of Holography, Recording and Reconstruction Method, Theory of Holography as Interference between two Plane Waves, Point source holograms.

Practical (Credit 1, Contact Hours 30)

(At least five experiments to be performed from the following)

1. Familiarization with: Schuster's focusing, determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
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.

Suggested Readings:

- 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.
- A textbook of Light, Ghosh and Mazumder
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.
- B. Sc. Practical Physics, C. L. Arora, S. Chand, and Company.
- A Text Book on Practical Physics, K. G. Mazumdar, and B. Ghosh.

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Subject: Physics (Major)

Semester: Four

Course Name: Thermal Physics
Course Code: PHY-MJ-04034
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To understand principles of thermodynamics
- To provide concepts of thermodynamic functions
- To address the basic framework of kinetic theory of gases

Course Outcome:

Upon completion of this course, students will be able to learn thermal properties of gas molecules and their collisions. With this course, students will acquire knowledge of thermodynamics with practical insights into thermal physics, which will help them to understand real world situations.

Title of the course	Thermal Physics
Course Code	PHY-MJ-04034
Total Credit	3 Theory + 1 Practical
Contact hours	40(L) + 5(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary :

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Principles of Thermodynamics	8	5	30	75
II	Entropy	7			
III	Thermodynamic Potentials and Thermodynamic Relations	14			
IV	Distribution of Velocities and Molecular Collisions	5			
V	Real Gases	6			

DETAILED SYLLABUS

Thermal Physics

Theory (Credit 3)

Unit I: Principles of Thermodynamics **Lectures 8**

Thermodynamic preliminaries: Extensive and intensive properties, Thermodynamic Variables, Thermodynamic Equilibrium, P-V indicator diagram. Work done in terms of P and V, Zeroth Law of Thermodynamics & Concept of Temperature, Internal energy and First Law of Thermodynamics, Applications of First Law: General Relation between *C*P and *C*V. Reversible and Irreversible process with examples. Heat & work, state function, Conversion of heat into work and vice versa, Work Done during Isothermal and Adiabatic Processes, Heat Engines, second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence, Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit II: Entropy **Lectures 7**

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

Unit III: Thermodynamic Potentials and Thermodynamic Relations **Lectures 14**

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Energy equations, (5) Change of Temperature during Adiabatic Process.

Unit IV: Distribution of Velocities and Molecular Collisions **Lectures 5**

Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, and (2) Thermal Conductivity. Brownian Motion (qualitative idea only).

Unit V : Real Gases : **Lectures 6**

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. Vapor 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. Joule- Thomson Porous Plug Experiment. Joule- Thomson Effect, Joule-Kelvin coefficient for Ideal and Van der Waal Gases. Temperature of Inversion.

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following

1. To determine mechanical equivalent of heat, J, by Callender and Barne's constant flow method.
2. To determine the mechanical equivalent of heat, J using calorimeter.
3. To determine specific heat of a liquid using calorimeter.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the coefficient of thermal conductivity of an insulator by Lee and Charlton's disc method.
6. To determine the temperature coefficient of resistance by Platinum Resistance Thermometer (PRT).
7. To study the variation of thermo-emf of a thermocouple with difference of temperature of its two junctions.
8. To determine the change of entropy of universe for an AC circuit consists of a thermally insulated resistor.
9. To calibrate a thermocouple to measure temperature in a specified range using (i) Null method, (ii) Direct measurement using OPAMP and to determine neutral temperature.

Suggested Readings:

- Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
- A Treatise on Heat, Meghnad Saha and B. N. Srivastava, Indian Press, 1973.
- Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C. Garg, R. M. Bansal and C . K. Ghosh, Tata McGraw Hill Education Pvt Ltd, 2013 .
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G. L. Salinger, Narosa Publishing House, 1998.
- Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
- Theory and Experiment on Thermal physics, P K. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

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Subject: Physics (Major)

Semester: Four
Course Name: Quantum Mechanics I
Course Code: PHY-MJ-04044
Credit: 4 (3 Theory + 1 Practical)

Course Objective:

The objective of the course is to impart broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation has been discussed along with its applications.

Course Outcomes:

- The learner will receive a broad overview of the history of quantum mechanics and its gradual development. Schrödinger equation which is one of the important equation for studying quantum mechanical systems will be learned along with other aspects like operator formulism of quantum mechanics, principle of uncertainty and complementarity, etc.
- They will learn to apply the formulism learned so far to investigate quantum mechanical systems like simple harmonic oscillator, hydrogen atom, etc.
- This knowledge will help in understanding other branches in Physics like Solid State Physics, Nuclear Physics, Spectroscopy, Astrophysics, optics, etc.

Title of the course	**Quantum Mechanics I**
Course Code	**PHY-MJ-04044**
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary :

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Origin of Quantum Theory	15	0	30	75
II	Schrödinger's equation	12			
III	Postulates of Quantum Mechanics	5			
IV	Application of Schrödinger's equation in one dimensional potential well	13			

DETAILED SYLLABUS

Quantum Mechanics I

Theory (Credit 3)

Unit I: Origin of Quantum Theory **Lectures 15**

Origin of Quantum Theory - Inadequacy of classical physics, Planck's quantum hypothesis, Photo elecric effect, Compton Effect, Wave-particle duality - de-Broglie hypothesis and genesis of Quantum Mechanics, Verification of matter wave - Davisson-Germer's experiment. Wave description of particles by wave packets. Group and phase velocities and relation between them. Two-slit experiment with electrons. Probability. Wave amplitude and wave functions. Uncertainty and complementarity - Heisenberg's uncertainty principle and complementarity principle of Neil Bohr, limitations on experiment.

Unit II: Schrödinger's equation **Lectures 12**

Development of the wave equation, time dependent Schrödinger's equation, Time independent Schrödinger Equation; Statistical interpretation wave function, Continuity of a wave function, Conditions for physical acceptability of wave functions. Normalization. Linearity and Superposition Principles. Boundary conditions, probability and probability current density, expectation value of position and momentum, operator, Ehrenfest's theorem,

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

Unit III: Postulates of Quantum Mechanics **Lectures 5**

Postulates of quantum mechanics, observables, hermitian operators, eigenvalues and eigenfunction, uncertainty principle (including time and energy).

Unit IV: Application of Schrödinger's equation in 1D potential well **Lectures 13**

Schrödinger's equation in one dimensional step potential, potential barrier - reflection and transmission coefficients and tunneling effect, square well potential with infinite depth, one dimensional harmonic oscillator. Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy and uncertainty principle.

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following

1. To Measure of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: To measure 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 Hα emission line of hydrogen atom.
6. To determine the ionisation 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's oil drop apparatus and determine the charge of an electron.
10. To show the tunnelling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction from single slit.
12. To determine the wavelength of laser source using diffraction from double slits.
13. To determine (i) wavelength and (ii) angular spread of He-Ne laser using plane diffraction grating.

Suggested Readings:

- N. Zettili, Quantum Mechanics, John Wiley & Sons (2001).
- J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics, Cambridge Univ. Press, 2020.
- Y. R.Waghmare, Fundamentals of Quantum Mechanics, Wheeler publishing (2014).
- R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).
- D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
- L. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
- A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2002).
- A. Bieser, Concepts of Modern Physics, McGraw Hill (2002).
- H. C. Verma, Quantum Mechanics, TBS publications (2019).
- P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics, 2nd Edition, McGraw Hill (2010).
- Satya Prakash, Quantum mechanics, 4th Edition, Pragati prakashan (2009).

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Subject: Physics (Major)
Semester: Five
Course Name: Electromagnetic Theory I
Course Code: PHY-MJ-05014
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To lay the foundation of electromagnetism through Maxwell's equations.
- Behaviour of electromagnetic waves as it propagates through vacuum and other media.
- Various effects that occur as electromagnetic waves propagate from one medium to another medium.
- Basic concepts of fibre optics.
- Various aspects of electromagnetic wave polarisation

Course Outcome:

After the successful completion of the course, students will acquire the concepts of Maxwell's equations, propagation of electromagnetic (EM) waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized EM waves, and fibre optics.

Title of the course	Electromagnetic Theory I
Course Code	PHY-MJ-05014
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Maxwell's equations	04	0	30	75
II	EM waves	04			
III	EM wave propagation in a dielectric and conductor	12			
IV	Polarization of Electromagnetic Waves	15			
V	Rotatory Polarization	06			
VI	Optical fibres	04			

DETAILED SYLLABUS

Electromagnetic Theory I

<u>Theory (Credit 3)</u>

Unit I: Maxwell's equations **Lectures 4**

Maxwell's equations, Vector and Scaler Potentials, D'Alembertian Operator. Poynting Vector.

Unit II: EM waves **Lectures 4**

Review of wave equation. Plane electromagnetic waves through vacuum. Perpendicular nature of E, B and k. Refractive Index of electromagnetic waves and its relation to dielectric constant of a dielectric.

Unit III: EM wave propagation in a dielectric and conductor **Lectures 12**

Reflection and refraction of plane EM waves at interface between two dielectric media (Boundary conditions). Proof of the laws of reflection and reflection using boundary conditions. Fresnel's Formula. Proof of Brewster's Law. Reflection and transmission coefficients of EM waves at dielectric interface. Propagation of EM waves through a conducting media. Concept of relaxation time and skin depth.

Unit IV: Polarization of Electromagnetic Waves **Lectures 15**

Linearly, Circularly and Elliptically Polarized light. Uniaxial and bi-axial crystals. Light propagation in uniaxial crystal. Double refraction. Polarization by double refraction. Nicol prism. Ordinary and extra-ordinary light ray and their refractive indices. Production and detection of plane, circularly and elliptically polarized light. Quarter-wave plate and half wave plate. Babinet's compensator and its uses to analyse polarized light.

Unit V: Rotatory Polarization **Lectures 6**

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.

Unit VI: Optical fibres **Lectures 4**

Numerical Aperture. Step and graded indices. Single and multiple mode fibres.

<u>Practical (Credit 1, Contact Hours 30)</u>

At least five experiments to be performed from the following

1. To verify the law of Malus for plane polarised light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarised light by usingBabinet'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 and 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 polarisation 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 characteristic of pn junction diode.

Suggested Readings:

- Introduction to Electrodynamics, D. J. Griffiths.
- Electromagnetics, B. B. Laud, New Age International Publishers.
- Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning.
- Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson
- Education.
- Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill.
- Electromagnetic Field Theory, R. S. Kshetrimayun, 2012, McGraw Hill.
- Engineering Electromagnetic, Willian H. Hayt, 2012, McGraw Hill.
- Electricity and Magnetism [With electromagnetic theory and special theory of relativity],
- D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.

Course designed by-

i) Dr. Dibya Jyoti Sivananda, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Rajib Kumar Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Archana Haloi, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)

Semester: Five
Course Name: Atomic and Nuclear Physics
Course Code: PHY-MJ-05024
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To learn the development of atom models.
- To learn the origin of atomic spectra and their modifications under different physical conditions.
- To impart basic knowledge about the nucleus and other subatomic particles and their properties.
- To impart knowledge about the radioactive disintegration of a nucleus and the laws of radioactive decays.
- To impart knowledge on basic nuclear instrumentation and experimental techniques of nuclear physics.
- To impart basic knowledge of particle physics.

Course Outcome:

Students will be able to understand the atomic spectra of one and two valance electron atoms and will also understand the change in behavior of atoms and corresponding modification of their spectra in external applied electric and magnetic field.

Students will also be able to understand the structure and properties of a nucleus. They will also know about the properties of strong nuclear force that keeps the nuclei bound. They will learn about the radioactive decays and various laws of radioactive disintegration. Students will have adequate knowledge on the construction and working principles of particle accelerators and detectors. Moreover, students will be introduced to the world of particle physics – types and interactions.

The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

Title of the course	Atomic and Nuclear Physics
Course Code	PHY-MJ-05024
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution ofMarks	Internal Assessment:40 End Semester Examination:Theory=60

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
Part A: Atomic Physics			5	0	60
I	Atom Model	10			
II	X- Rays	4			
III	Multi electron atoms	6			
Part B: Nuclear Physics					
I	Basic Properties of Nuclei	8			
II	Radioactivity and Radioactive Laws	5			
III	Nuclear Instrumentation	10			
IV	Fission and Fusion	7			
V	Elementary Particles	5			

DETAILED SYLLABUS
Atomic and Nuclear Physics

Theory (Credit 4)

Part A: Atomic Physics

Unit I: Atom Model **Lectures 10**

The Bohr model of the hydrogen-like atom. Orbital magnetic dipole moment: Bohr Magneton. Gyromagnetic Ratio, Larmor precession, Space Quantization, Electron Spin. Vector Atom Model : Quantum numbers associated with vector atom model, spin-orbit interaction, Coupling Schemes: L-S Coupling and j-j Coupling, Spectroscopic term and their notation, Stern-Gerlach experiment and its conclusion. Normal and Anomalous Zeeman Effect.Paschen Back and Stark Effect (Qualitative Discussion only).

Unit II: X-Rays **Lectures 4**

Ionizing Power, X-ray Diffraction, Bragg's Law, X-ray Spectra: Continuous and characteristic X-rays, Mosley's law, Compton effect.

Unit – III: Multi-Electron Atoms **Lectures 6**

Hund's rule, Periodic table: Pauli's exclusion principle, explanation of the periodic classification of the elements, Building up or Aufbau Principle, Broad features of Alkali atom (Na etc.), spectra and its explanation.

Part-B : Nuclear Physics

Unit I: Basic Properties of Nuclei **Lectures 8**

Constituents of a nucleus: proton-electron hypothesis. Properties of nucleus - mass, radius, volume, matter density of nuclei and their units. Mass defect and Binding energy, binding energy per nucleon, stability of a nucleus- neutron to proton ratio, stability line. Nuclear Models: Liquid Drop Model, Shell Model (Qualitative only).

Unit – II : Radioactivity and Radioactive Laws **Lectures 5**

Types of Radioactivity – alpha, beta, and gamma decay. Laws of radioactive decay, disintegration constant, half-life and mean life. Activityof a radioactive source, units of radioactivity.

Unit II : Nuclear Instrumentation **Lectures 10**

Interaction of Radiation with Matter: Interaction of photon with matter – Photoelectric effect, Compton effect and Pair production. Detectors: Gas filled detectors – Pulse height Vs applied voltage graph. Construction and working principle of G. M. counter. Particle Accelerators : Need of charged particle accelerators, Linear accelerator (LINAC) – Construction and working principle, Cyclotron.

Unit IV: Fission and Fusion **Lectures 7**

Mass defect and Q-value of a nuclear reaction, Einstein's mass-energy equivalence principle and generation of nuclear energy. Nuclear Fission: Spontaneous and induced fission. Fission chain reactions and nuclear reactor. Fusion and thermonuclear reactions: Energy production in stars, P-P cycle and CNO cycle (brief qualitative discussions).

Unit V: Elementary Particles **Lectures 5**

Types of interactions – strong, electro-magnetic, weak interactions and gravitational interactions. Elementary particle and their classification. Quantum numbers and conservation laws. Allowed and forbidden reactions. Gellman-Nishijima equation. Eight-fold way classification, I_3-Y plots of Elementary particles. Colour quantum number (definition only).

Suggested Readings:

- Introduction to Atomic spectra, H. E. White, Tata McGraw Hill (1934)
- Atomic and Molecular Spectra, Raj Kumar
- Concepts of Modern Physics, Arthur Beiser (McGraw-Hill Book Company, 1987)
- Atomic physics, J. B. Rajam & foreword by Louis De Broglie (S. Chand & Co., 2007)
- Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash
- Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
- Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
- Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
- Nuclear Radiation Detector by S S Kapoor and V S Ramamurthy , 1st edition, New Age international publisher.

Course designed by –

i) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Prof. Manoj Kr. Sarma, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam

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Subject: Physics (Major)

Semester: Five
Course Name: Analog and Digital Electronics
Course Code: PHY-MJ-05034
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- Develop foundational understanding of analog and digital electronics, focusing on core devices, circuit analysis, and applications.
- Build competence in analog circuit design, including rectifiers, amplifiers, feedback circuits, and oscillators.
- Provide a conceptual and practical grasp of operational amplifiers and their applications in arithmetic and waveform processing.
- Impart the basic principles of Boolean algebra, combinational and sequential digital circuits, and circuit simplification.
- Foster hands-on skills through laboratory experiments encompassing both analog and digital circuits, promoting practical understanding and problem-solving.

Course Outcome:

On successful completion of the course students will be able to

- Interpret and understand the working principles of basic semiconductor devices and their roles in analog and digital circuits.
- Analyze and design basic analog circuits such as rectifiers, amplifiers (RC-coupled and power), voltage regulators, and oscillators.
- Utilize operational amplifiers to create inverting/non-inverting amplifiers, adders, subtractors, integrators, and differentiators.
- Apply Boolean algebra for circuit simplification and implement combinational logic circuits, including adders and basic arithmetic units.
- Describe and build logic circuits, basic arithmetic and sequential circuits and explain their applications.
- Demonstrate competence in basic circuit assembly, measurement, and troubleshooting using breadboards and standard components in laboratory settings.

Title of the course	Analog and Digital Electronics
Course Code	PHY-MJ-05034
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45, Practical=25

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
Part A: Analog Electronics				30	75
I	Semiconductor Diodes and their Applications	7	0		
II	Bipolar Junction Transistors	4			
III	Hybrid Parameters	3			
IV	Amplifiers	6			
V	Feedback Amplifier and Oscillator	4			
VI	Operational Amplifiers (Black Box approach)	6			
Part B: Digital Electronics					
I	Unit I: Digital Circuits	6	0		
II	Unit II: Boolean Algebra	2			
III	Unit III: Arithmetic Circuit	3			
IV	Unit IV: Sequential Circuit	4			

DETAILED SYLLABUS
Analog and Digital Electronics

Theory (Credit 3)

Part A: Analog Electronics

Unit I: Semiconductor Diodes and their Applications **Lectures 7**

Introduction to P-N junction diode, Volt-ampere relation of P-N junction diode (deduction not necessary), Energy band diagram of P-N diode. Special purpose diodes (introduction only). Half wave and full wave with resistive load, Efficiency, Ripple factor, filters- series inductor, shunt capacitor, L-section and Π-section. Zener diode, Voltage regulation and regulated Power Supply.

Unit II: Bipolar Junction Transistors **Lectures 4**

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, Active, Cut-off, and Saturation Regions.

Unit III: Hybrid Parameters **Lectures 3**

Two port (four terminals) device and h parameters, h parameter equivalent circuit, analysis of transistor amplifier (CE) with h parameters, current gain, voltage gain and power gain, input and output impedance.

Unit IV: Amplifiers **Lectures 6**

Classification of amplifiers, Class A, Class B and Class C amplifiers, cascade amplifiers. Small signal RC coupled amplifier (CE) and its voltage and current gain in low, mid and high frequency, frequency response curve, Phase relation between input and output.

Unit V: Feedback Amplifier and Oscillator **Lectures 4**

Effects of Positive and Negative Feedback on Input Impedance. Output Impedance, Gain, Stability, Distortion and Noise. Sinusoidal Oscillators, Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator (basics only).

Unit VI: Operational Amplifiers (Black Box approach) **Lectures 6**

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. Inverting and non-inverting amplifiers. Adder. Subtractor. Differentiator. Integrator. Log and Anti Log amplifier. Zero crossing detector. Comparator.

Part B: Digital Electronics

Unit I: Digital Circuits **Lectures 6**

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.

Unit II: Boolean Algebra **Lectures 2**

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra.

Unit III: Arithmetic Circuit **Lectures 3**

Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders

Unit IV: Sequential Circuit **Lectures 4**

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip- Flops, Preset and Clear operations (basics only).

Practical (Credit 1; Contact hours 30)

Minimum eight experiments (four from Part A and four from Part B) should be performed

Part A: Analog Electronics

1. To Study V- characteristics of p-n junction diode and determine cut-in voltage using breadboard.

2. To draw the forward and reverse bias characteristic of a Zener diode and hence determine their DC and AC resistances. Also determine the breakdown voltage of the Zener diode (Using Breadboard).
3. To design voltage regulator using Zener diode and study the load and line regulation (Using Breadboard).
4. To study the input and output characteristics of a transistor in CB and CE configurations and determine the alpha and beta of the transistor.
5. To draw the frequency response curve of RC coupled common emitter amplifier and hence determine 3dB points and band width.
6. To assemble and study the frequency response of an OPAMP in inverting negative feedback mode for different feedback resistances and hence calculate upper half power point and band width.
7. To study the transfer characteristic of an OPAMP in negative feedback mode for different feedback loop.
8. To design (a) adder and (b) subtractor circuit using OPAMP IC.
9. To design and study (a) Integrating and (b) Differentiating circuit using OPAMP IC.

Part B: Digital Electronics

1. To verify De Morgan's theorem using IC 7400 and 7402. (Using Breadboard).
2. To design (a) OR, (b) AND, (c) NOT and (d) NAND gate with resistance, diode and transistors using bread board and verify their truth table. (Using Breadboard).
3. To design OR, AND and NOT gates using universal gates and verify their truth table using breadboard.
4. To design a Half Adder and Full Adder.
5. To build and study SR flip-flop circuits using NAND/NOR gate.
6. To build and study D flip-flop circuits using NAND/NOR gate.
7. To build a JK flip-flop circuit using NAND gates.

Suggested Readings:

- Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning
- Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
- Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd Ed., 2002, Wiley India
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
- Electronics Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, 17th Ed, 2023, New Age International Publishers
- Principles of Electronics, V. K. Mehta, Rohit Mehta, 11th Ed. 2008, S. Chand.
- 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.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

Course designed by:

i) Dr. Rajib Kr. Basumatary, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

ii) Dr. Barsha Borgohain, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

iii) Prof. Arup Kr. Deka, Assistant Professor, Department of Physics, Darrang College (Autonomous), Tezpur, Assam

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Subject: Physics (Major)
Semester: Six
Course Name: Condensed Matter Physics
Course Code: PHY-MJ-06014
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To provide the elementary idea about crystal structure, bonding and lattice dynamics in solids.
- To make the students understand the concepts of transport properties, dielectric properties, ferroelectric properties and magnetic properties in solids.
- To familiarise the students with nanomaterials, thin film, soft matter and superconductivity.

Course Outcome:

On successful completion of the course students will be able

- To acquire the basic knowledge of crystal structure and bonding in solids
- To understand elementary idea lattice dynamics of materials
- To gain knowledge about dielectric, ferroelectric and magnetic properties of solids
- To acquire basic idea about nanomaterials, thin film and soft matter
- To understand the basic concept in superconductivity.

Title of the course	Condensed Matter Physics
Course Code	PHY-MJ-06014
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45, Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Crystal Structure and Bonding in Solids	9	0	30	75
II	Lattice Vibrations	4			
III	Dielectric and Ferroelectric Properties of Materials	10			
IV	Transport properties of Materials	9			
V	Nanophysics and Soft Matter	3			
VI	Magnetic Properties of Matter	7			
VII	Superconductivity	3			

DETAILED SYLLABUS
Condensed Matter Physics

Theory (Credit 3)

Unit 1: Crystal Structure and Bonding in Solids **Lectures 9**

Amorphous, crystalline and polycrystalline materials, lattice translation vectors, unit cell, types of crystal lattice, Bravais Lattice, Miller Indices, inter planer spacing. Ionic, covalent, metallic, van-der-Waal and hydrogen bondings, cohesive energy of ionic crystal, Madelung constant.

Unit 2: Lattice Vibrations **Lectures 4**

Basic idea of lattice vibration and phonon, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, Debye's T3 law.

Unit 3: Dielectric and Ferroelectric Properties of Materials **Lectures 10**

Polarization. local electric field at an Atom, depolarization field, electric susceptibility, polarizability. Clausius Mosotti equation, classical theory of electric polarizability, normal and anomalous dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation. Piezoelectric effect, pyroelectric effect, ferroelectric effect, Electrostrictive effect, Curie-Weiss Law.

Unit 4: Transport properties of Materials **Lectures 9**

Free Electron Theory of Metals, Electrical and thermal conductivity of metals, Wiedemann-Franz law, drawback of classical theory and modification with quantum theory, preliminary idea of band theory, band gap, conductor, semiconductor (p and n type) and insulator, conductivity of semiconductor, mobility, measurement of conductivity (2-probe & 4-probe resistivity measurement method), Hall Effect (Qualitative idea).

Unit 5: Nanophysics and Soft Matter **Lectures 3**

Basic idea about nanomaterials, thin film physics and soft matter.

Unit 6: Magnetic Properties of Matter **Lectures 7**

Dia, para, ferri, ferro and anti-ferromagnetic materials, classical Langevin Theory of dia and paramagnetism, Curie's law, Weiss' theory of ferromagnetic domains, discussion of $B - H$ Curve, hysteresis and energy Loss.

Unit 7: Superconductivity **Lectures 3**

Basic idea of superconductivity, critical temperature, critical magnetic field, Meissner effect. Type I and type II Super- conductors, isotope effect.

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following

1. Indexing of powder X-Ray diffraction data of cubic crystalline materials and determination of lattice parameters including inter planner spacing (XRD data needs to arrange by the department).
2. Measurement of susceptibility of a paramagnetic solution (Quinck's Tube Method).
3. To measure the magnetic susceptibility of solids.
4. To determine the Coupling Coefficient of a piezoelectric crystal.
5. To measure the Dielectric Constant of a dielectric materials with frequency.
6. To study the P-E Hysteresis loop of a Ferroelectric Crystal.
7. To draw the $B - H$ curve of Fe using Solenoid & determine energy loss from Hysteresis.
8. To measure the variation of resistivity of a semiconductor with temperature by four probe method and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample

Suggested Readings:

- Introduction to Solid State Physics, C Kittel
- Lattice Dynamics, A K Ghatak and L S Kothari
- Solid State Physics, A J Dekker.
- Introductory Solid State Physics, H P Myers.
- Solid State Physics, N W Ashcroft and N D Mermin
- Magnetism in solids, D H Martin
- Physics of Magnetism, S Chikazumi. 8. Solid State Physics, S O Pillai
- Introduction to Nanotechnology, C. P. Poole, J. F. J. Owens

Course designed by –

i) Dr. Barsha Borgohain, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

ii) Dr. Shyamalima Chowdhury, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

iii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Six
Course Name: Statistical Mechanics
Course Code: PHY-MJ-06024
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

- To illustrate the purpose of Statistical Mechanics
- To study statistical behavior of many particle system
- To learn different thermodynamic functions
- To learn classical and quantum mechanical theories of radiation

Course Outcome:

Upon completion of the course, students will learn the basics of statistical mechanics and the governing distribution laws and application of Statistical Mechanics to other related fields

Title of the course	Statistical Mechanics
Course Code	PHY-MJ-06024
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45, Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Classical Statistics	15	0	30	75
II	Classical and Quantum Theory of Radiation	12			
III	Bose-Einstein Statistics	8			
IV	Fermi-Dirac Statistics	10			

DETAILED SYLLABUS
Statistical Mechanics

Theory (Credit 3)

Unit I: Classical Statistics **Lectures 15**

Microstate and macrostate, distributions of particles in compartments, principle of equal a priori probability. Phase space, volume of phase space. Elementary concept of ensembles, Types of ensembles. Ergodic hypothesis. Entropy and thermodynamic probability, Stirling's approximation, Maxwell-Boltzmann distribution function, Partition functions. Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) — Applications to specific heat and its limitations. Thermodynamic parameters (internal energy, entropy, free energy, enthalpy) using partition functions.

Unit II: Classical and Quantum Theory of Radiation **Lectures 12**

Properties of thermal radiation, Blackbody radiation, Spectral distribution of Blackbody radiation, Kirchhoff's law, Stefan-Boltzmann law, Thermodynamic proof, Radiation pressure (for Normal and diffused case). Wien's Displacement law, Wien's Distribution Law, Saha'sionization formula, Rayleigh-Jean's Law (with proof). Ultraviolet catastrophe,Need of quantum statistics, Planck's quantum postulates, Planck's law of blackbody radiation: Experimental verification. Deduction of (1) Wien's Distribution Law, (2) RayleighJeans Law, (3) Stefan- Boltzmann Law, (4) Wien's Displacement law from Planck's blackbody radiation formula

Unit III: Bose-Einstein Statistics **Lectures 8**

Bose-Einstein (BE) distribution, Pressure of a Bose gas, Bose Einstein Condensation (qualitative description only), Properties of liquid Helium (qualitative discussion only), Radiation as a photon gas and Bose's derivation of Planck's blackbody radiation formula, Thermodynamic functions of photon gas– energy, entropy, and free energy

Unit IV: Fermi-Dirac Statistics **Lectures 10**

Fermi-Dirac (FD) distribution, FD function and Fermi Energy, Degenerate Fermi gas, strongly degenerate case (qualitative discussion only),Thermodynamic functions - energy and pressure of a completely degenerate Fermi gas, Heat capacity at low temperature, Free electron gas in metals and electronic specific heat, thermodynamics of white dwarf star (qualitative discussion only)

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics.

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   (a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations.
   (b) Study of transient behaviour 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_θ,
   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

Suggested 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

Course designed by –

i) Dr. Shyamalima Chowdhury, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Prof. Arup Kr. Deka, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Six
Course Name: Classical Mechanics and Astrophysics
Course Code: PHY-MJ-06034
Credit: 4 (3 Theory + 1 Practical)

Course Objectives:

The basic objectives of the course are

- To introduce the laws of classical dynamics
- To train students in solving problems of motion of particles, systems of particles and fluids and to introduce the students with fundamental concepts and observational techniques in astronomy.

Course Outcome:

On successful completion of the course students will be able to apply the laws of classical dynamics to physical problems of motion of particles, systems of particles and fluids in various fields of physics and natural science as a whole. On successful completion of this course students will be able to understand the fundamental concepts in astronomy. They will be able to apply physics of celestial objects in understanding the universe.

Title of the course	Classical Mechanics and Astrophysics
Course Code	PHY-MJ-06034
Total Credit	4 (Theory)
Contact hours	55(L) + 5(T) + 0(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45, Practical=25

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
Part A: Classical Mechanics			5	0	60
I	Lagrangian Dynamics	18			
II	Hamiltonian Dynamics	09			
III	Fluid Dynamics	08			
Part B: Astrophysics					
I	Fundamentals of Astronomy	6			
II	Stellar Astrophysics	8			
III	Galaxies and cosmology	6			

DETAILED SYLLABUS
Classical Mechanics and Astrophysics

Theory (Credit 4)

Part A: Classical Mechanics

Unit I: Lagrangian Dynamics **Lectures 18**

Constraints: Holonomic and non-holonomic constraints and examples. Forces of constraints. Difficulties introduced by constraints and their removal. Work done by constraints. Generalised co-ordinates and their importance, principle of virtual work. D' Alembert's principle. Generalized momenta and velocities. Lagrange's equation: Lagrange's equation and solving problems. Newton's equation of motion from Lagranges's equation. Simple pendulum, compound pendulum, particle moving under a central force using Lagrange's equation and other simple problems. Discussion on superiority of Lagrangian mechanics over Newtonian approach.

Unit II: Hamiltonian Dynamics **Lectures 9**

Hamilton's Principle. Conjugate or generalized momentum. Hamiltonian as a Legendre transform of Lagrangian. Hamilton's equation of motion. Physical problems: examples can include simple pendulum, particle moving in a central force field and other problems.

Unit III: Fluid Dynamics **Lectures 8**

Definition of a Fluid. Fluid density and pressure of a fluid. Velocity of fluid element and its time derivative. Mass conservation and equation of continuity. Incompressible fluid. Euler's equation of fluid dynamics. Bernoulli's equation. Navier Stokes equation (introduction only).

Part B: Astrophysics

Unit I: Fundamentals of Astronomy **Lectures 6**

Celestial sphere and celestial coordinates system - altitude-azimuth (Alt-Az) and right ascension- declination (RA-DEC). Flux and luminosity of celestial objects; stellar magnitude scale – apparent and absolute magnitude. Measurement of stellar distances – trigonometric parallax.

Unit II: Stellar Astrophysics **Lectures 8**

Star formation from interstellar medium (introduction only); properties of stars – mass, luminosity, radius and effective surface temperature; mass-luminosity, mass-radius and luminosity-radius temperature relation. Spectral classification – HR diagram; stellar evolution- idea of nucleosynthesis in main sequence phase- pp and CNO cycle; Evolution of stars - red giants and white dwarfs - Chandrasekhar mass limit (introduction only); evolution of massive stars – neutron stars and black holes (introduction only).

Unit III: Galaxies and Cosmology **Lectures 6**

The Milky Way - shape, size and its components; classification of galaxies –Hubble's tuning fork diagram; types – spirals, elliptical and lenticular. Large scale structure of the universe – galaxies, clusters, superclusters, filaments, walls and voids. Cosmological Principle: Hubble's law; closed and oscillating universe, flat and open universe; Hot Big Bang model.

Suggested Readings:

- Classical Mechanics, H. Goldstein, C.P. Poole and J.L. Safko (Pearson Education)
- Theoretical Mechanics, M. R. Spiegel (McGraw Hill Book Company)
- Classical Mechanics, P.S. Joag and N.C Rana (McGraw Hill Book Company)
- Mathematical Physics, B. S. Rajput (Pragati Prakashan)
- Classical Mechanics, T.W.B. Kibble and F.H. Berkshire (Imperial College Press)
- Mechanics: Courses in Theoretical Physics (Vol. 1), L.D. Landau and E.M. Lifshitz
- (Butterworth-Heinemann) (3rd Edn.)
- Classical Mechanics: With introduction to non-linear oscillations and chaos, V.B.
- Bhatia (Narosa Publishing House)

Course designed by –

i) Dr. Dibyajyoti Sivananda, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Barsha Borgohain, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Six
Course Name: Minor Project and IKS in Astronomy
Course Code: PHY-MJ-06044
Credit: 4 (3 Practical + 1 Theory)

Course Objectives:

- To introduce the students to preliminary research work,
- To introduce ancient astronomy and ancient Indian astronomers and their contributions towards astronomy.
- To introduce the students with fundamental concepts and observational techniques in astronomy.

Course Outcome:
On successful completion of this course students will
- acquire the basic preliminary skills of experimental or theoretical research work in Physics.
- have a glimpse of ancient Indian Astronomy.
- gain knowledge on how the people could have the idea about different phases of night by observing the positions of certain stars in the sky by necked eyes.

Course Summary :

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
Part A: Minor Project					
Part B: IKS in Astronomy					
I	Unit - I : Night sky observation	5	2	0	15
II	Unit - II : Devising calendar	4			
III	Unit - III : Classification of ancient Indian Astronomy	4			

DETAILED SYLLABUS:
Minor Project and IKS in Astronomy

Part A: Minor Project (Credit 3)

Students will have to do a minor project under the guidance of a supervisor.

Part B: IKS in Astronomy (Credit 1)

Unit I: Night sky observation **Lectures 5**

Night sky observation in ancient times with unaided eyes, position and movement of stars and celestial objects. Estimation of time from the positions of certain stars in the sky.

Unit II: Devising calendar **Lectures 4**

Devising calendar, crop plantation, direction determination, religious faiths and rituals.

Unit III: Classification of ancient Indian Astronomy **Lectures 4**

Classification of ancient Indian Astronomy – Vedic Astronomy and post Vedic Astronomy. Ancient astronomers and their contributions towards astronomy.

Suggested Readings:

- Astrophysics for physicists, A. Rai Choudhuri, Cambridge University Press.
- Astrophysics- Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill Pub.
- Textbook of astronomy and astrophysics with elements of cosmology, V. B. Bhatia, Narosa Pub.
- Introduction to astrophysics, H.L. Duorah and K. Duorah, Mani Manik Prakash (Guwahati).

Course designed by –

i) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Archana Haloi, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Seven
Course Name: Advanced Mathematical Physics
Course Code: PHY-MJ-07014
Credit: 4 (3 Theory + 1 Practical)

Course Objective:

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Course Outcome:

Upon completion of this course, students will be able to solve problems in Physics related to Linear Vector Space, Matrix Algebra, Tensor.

Title of the course	Advanced Mathematical Physics
Course code	PHY-MJ-07014
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Linear Vector Spaces	15	0	30	75
II	Matrix	8			
III	Cartesian Tensors	15			
IV	General Tensors	7			

DETAILED SYLLABUS
Advanced Mathematical Physics

Theory (Credit 3)

Unit I: Linear Vector Spaces **Lectures 15**

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector

Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformation by matrices.

Unit II: Matrix **Lectures 8**

Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. Co-ordinate transformations, rotation in two dimensions, rotation in three dimensions. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

Unit III: Cartesian Tensors **Lectures 15**

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities.
Moment of Inertia Tensor. Stress and Strain Tensors.

Unit IV: General Tensors **Lectures 7**

Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

<u>Practical (Credit 1, Contact Hours 30)</u>

Scilab/Mathematica/C ++ or others based simulations experiments based on Mathematical Physics problems like

1. Linear algebra

    - Multiplication of two 3×3 matrices
    - Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \quad \begin{pmatrix} 2 & -i & 3+4i \\ i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Lagrangian formulation in Classical Mechanics with constraints.
5. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).

Suggested Readings:

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W.Cheney&D.R.Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicis& Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
- Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

Course designed by –

i) Dr. Archana Haloi, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Prof. Manoj Kr. Sarma, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Seven
Course Name: Atomic, Molecular and Laser Physics
Course Code: PHY-MJ-07024
Credit: 4 (3 Theory + 1 Practical)

Course Objective::

The objective of this course is to provide students with a comprehensive understanding of the fundamental concepts and applications in atomic physics, molecular spectroscopy, and laser physics. The course aims to develop both theoretical knowledge and practical analytical skills needed to interpret atomic and molecular spectra and to understand the operational principles and applications of various laser systems.

Course Outcome:

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

- Analyze atomic and molecular spectral lines and deduce parameters such as length, mass, time, and energy from experimental data.
- Explain the mechanisms behind important physical effects including the Zeeman, Paschen–Back, and Stark effects; and describe the origin of broadening of spectral lines.
- Interpret rotational, vibrational, and electronic spectra of molecules, apply selection rules, and distinguish features of IR, Raman, and electronic spectra.
- Demonstrate understanding of laser operation, including spontaneous and stimulated emission, population inversion, and rate equations for different laser systems.
- Identify and describe the construction and functioning of ammonia maser, ruby laser, He-Ne laser, and CO_2 lasers, as well as their applications such as holography and optical communication.

Title of the course	Atomic, Molecular and Laser Physics
Course code	PHY-MJ-07024
Total Credit	4 (3 Theory + 1 Practical)
Contact hours	45(L) + 0(T) + 30(P)
Distribution of Marks	Internal Assessment:30 End Semester Examination: Theory=45; Practical=25

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Atomic Physics	15	0	30	75
II	Molecular Physics	15			
III	Lasers	15			

DETAILED SYLLABUS

Atomic, Molecular and Laser Physics

Theory (Credit 3)

Unit I: Atomic Physics **Lectures 15**

Pauli exclusion principle: spectral terms from two equivalent electrons, Vector model for three or more valence electrons and spectral terms, branching rule, Landé interval rule, LS and j-j coupling schemes, energy levels, selection rules, spectra of oxygen, nitrogen and manganese atoms; Zeeman effect, Paschen- Back effect, Stark effect in hydrogen, hyperfine structure, determination of nuclear spin and nuclear g-factors, Breadth of spectrum lines: natural broadening, Doppler broadening, collision broadening, and Stark broadening.

Unit II: Molecular Physics **Lectures 15**

IR spectra - rotation, vibration and rotation-vibration spectra of diatomic molecules, selection rules, determination of rotational constants. Electronic spectra: Born-Oppenheimer approximation, vibrational structure of electronic transition, progressions and sequences of vibrational bands, Intensity distribution, Franck Condon principle. Raman spectra: Classical theory of Raman effect, Vibrational Raman spectrum, selection rules, Stokes and anti-Stokes lines, Rotational Raman spectrum, selection rule.

Unit III: Lasers **Lectures 15**

Basic elements of a laser, properties of laser light; spontaneous and stimulated emission: Einstein coefficients, light amplification, population inversion and threshold condition for laser oscillations, optical resonator modes of a rectangular cavity, rate equations: two-level, three-level and four-level systems; ammonia maser, ruby laser, He-Ne laser, CO2 lasers, laser applications: holography and optical communication.

Practical (Credit 1, Contact Hours 30)

At least five experiments to be performed from the following

1. Determine the velocity of ultrasound in given liquids.
2. Verify the Heisenberg's uncertainty principle using He-Ne laser.
3. Measure the resistivity and hence the band gap of a semiconductor using four-probe method.
4. Find the constant of ballistic galvanometer using i-H and d-H curves.
5. Determine the plateau of the given GM counter and its percentage slope. Hence, study the statistical fluctuation (with beta source).
6. Study the absorption of beta rays passing through different thickness of Al and determine the linear absorption coefficient.

Suggested Readings:

- Introduction to Atomic Spectra, H E White.
- Physics of Atoms and Molecules, B H Bransden and C J Joachain
- Fundamentals of Molecular Spectroscopy, C N Banwell and E M McCash.
- Spectra of Diatomic Molecules (Vol. 1), G Herzberg.
- Lasers and Nonlinear Optics, B B Laud.
- Lasers : Theory and Applications, K Thyagarajan and A K Ghatak.

Course designed by –

i) Dr. Dibyajyoti Sivananda, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Prof. Manoj Kr. Sarma, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Prof. Arup Kr. Deka, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Seven
Course Name: Classical Mechanics-II
Course Code: PHY-MJ-07034
Credit: 4 (Theory)

Course Objectives:

This course aims to provide students with a strong foundation in classical mechanics through an in-depth study of Lagrangian and Hamiltonian formalisms and their applications. Students will explore fundamental topics such as central force problems, rigid body dynamics, canonical transformations, and Hamilton-Jacobi theory, along with modern extensions like special relativity and fluid dynamics. The objective is to equip students with analytical tools to describe and solve complex physical systems, develop problem-solving skills, and gain insight into both linear and nonlinear dynamical systems.

Course Outcome:

Upon successful completion, students will be able to apply advanced classical mechanics principles to a variety of physical phenomena using Lagrangian and Hamiltonian methods. They will demonstrate the ability to analyze rigid body motion, central force problems, and oscillatory systems, and understand canonical transformations and action-angle variables. Furthermore, students will acquire familiarity with special relativity concepts and fluid dynamics and will be introduced to nonlinear dynamics and chaos, preparing them to extend these classical concepts to research and advanced study in physics and related fields.

Title of the course	Classical Mechanics-II
Course code	PHY-MJ-07034
Total Credit	4 (Theory)
Contact hours	55(L) + 5(T) + 0(P)
Distribution of Marks	Internal Assessment:40 End Semester Examination: Theory = 60

Course Summary:

Unit	**Topic**	**Lecture (hours)**	**Tutorial (hours)**	**Practical (hours)**	**Total (hours)**
I	Formalism of Classical Mechanics	14	5	0	60
II	Central Force Motion	6			
III	Rigid Body Dynamics	7			
IV	Theory of Canonical Transformation	7			
V	Hamilton-Jacobi & Action Angle Formalism	7			
VI	Theory of Small Oscillations	8			
VII	Nonlinear Dynamics	6			

DETAILED SYLLABUS
Classical Mechanics-II

Theory (Credit 4)

Unit I: Formalism of Classical Mechanics **Lectures 14**

Lagrangian and Hamiltonian formalisms and equations of motion - their applications to physical problems. Cyclic coordinates, Variational principle and Noether's theorem, symmetry & conservation laws; Special theory of relativity, addition of velocities, Lorentz transformations and the light cone, relativistic form of Lagrangian and Hamiltonian relativistic kinematics and mass–energy equivalence, Covariant form of electromagnetic equations and their Lorentz invariance.

Unit II: Central Force Motion **Lectures 6**

Central-force motion - two-body collisions, Kepler problem, Effective potential, Scattering in laboratory and centre-of-mass frames.

Unit III: Rigid Body Dynamics **Lectures 7**

Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudo forces. Principal axes and principal moments of inertia. Euler's equation of motion. Symmetric top motion and Foucault's pendulum.

Unit IV: Theory of Canonical Transformation **Lectures 7**

Poisson brackets and their properties; Canonical transformations and generating function. Hamilton's equation in terms of Poisson bracket, Jacobi identity.

Unit V: Hamilton-Jacobi & Action Angle Formalism **Lectures 7**

Hamilton's Jacobi theory and its application to solve central force problem. Action–angle variables, application to simple harmonic oscillator, planetary motion, adiabatic invariants.

Unit VI: Theory of Small Oscillations **Lectures 8**

Equilibrium and small oscillations, normal coordinates, normal modes, coupled oscillations, diatomic and triatomic molecules.

Unit-VII: Nonlinear Dynamics **Lectures 6**

Introduction to nonlinear systems, concept of catastrophe, bifurcation, chaos and strange attractors, fractals, physical examples.

Suggested Readings:

- Classical Mechanics, H. Goldstein, C.P. Poole and J.L. Safko (Pearson Education)
- Theoretical Mechanics, M. R. Spiegel (McGraw Hill Book Company)
- Classical Mechanics, P.S. Joag and N.C Rana (McGraw Hill Book Company)
- Mathematical Physics, B. S. Rajput (Pragati Prakashan)
- Classical Mechanics, T.W.B. Kibble and F.H. Berkshire (Imperial College Press)
- Mechanics: Courses in Theoretical Physics (Vol. 1), L.D. Landau and E.M. Lifshitz (Butterworth-Heinemann) (3rd Edn.)
- Classical Mechanics: With introduction to non-linear oscillations and chaos, V.B. Bhatia (Narosa Publishing House)

Course designed by –

i) Dr. Dibyajyoti Sivananda, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Barsha Borgohain, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Seven
Course Name: Nuclear and Particle Physics II
Course Code: PHY-MJ-07044
Credit: 4 (Theory)

Course Objectives:

- To learn properties of nucleus and its constituents
- To learn nuclear techniques and their applications in different branches of physics
- To learn about nuclear detectors and nuclear accelerators.

Course outcome:

After completion of the course the students will be able to apply their knowledge in the areas of nuclear, medical archeology, Geology and other interdisciplinary fields of Physics and Chemistry

Title of the course	Nuclear and Particle Physics II
Course code	PHY-MJ-07044
Total Credit	4 (Theory)
Contact hours	55(L) + 5(T) + 0(P)
Distribution of Marks	Internal Assessment:40 End Semester Examination: Theory=60

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	General Properties of Nuclei	4	5	0	60
II	Nuclear Models	8			
III	Nuclear Reaction	8			
IV	Forces between Nucleons	7			
V	Nuclear Instrumentation	15			
VI	Nuclear Decay	8			
VII	Elementary Particles	5			

DETAILED SYLLABUS
Nuclear and Particle Physics II

Theory (Credit 4)

Unit I: General Properties of Nuclei **Lectures 4**

Basic Nuclear Properties: size, shape and charge distribution, spin, parity and isospin of nucleon and nuclei.

Unit II: Nuclear Models **Lectures 8**

Liquid drop Model: Semi empirical mass formula and its applications in - (i) Estimation of energy released in fission reactions, (ii) predicting the most stable member of an isobaric family, (iii) predicting the condition for spontaneous fission. Failure of Liquid drop Model. Shell Model: Magic numbers and experimental evidences of shell models, Single particle shell model and its application in predicting the spin and parity of even A and odd A nuclei, Failures of extreme single particle shell model. Concepts of collective model of nuclei.

Unit III: Nuclear Reaction **Lectures 8**

Concept of two body nuclear reaction for fixed target experiments - concept of flux, fluence, pnA, solid angle, cross-section, Classifications of nuclear reactions, Kinematics of two body nuclear reaction - Lab and CMS co-ordinate systems, Rutherford alpha particle scattering experiment - corrections for extended object,quantum mechanical and relativistic effects. Concept of nuclear reaction - Bohr compound nucleus hypothesis and Ghosal experiment.

Unit IV: Forces between Nucleons **Lectures 7**

Two nucleon system - bound state problem, Characteristics of nucleon-nucleon interactions, Deuteron as the simplest two body bound system - its ground state spin, parity, magnetic dipole and electric quadruple moments, experimental values, concept of non-central nuclear force, Deuteron ground state with squarewell potential.

Unit V: Nuclear Instrumentation **Lectures 15**

Part A: Radiation Detectors

Interaction of charged particles and radiation with matter, detector response, efficiency and resolution of a detector. Gas filled detector: current vs applied voltage curve, Ionisation region, Proportional region, GM region and spark region. Construction and working principle of GM counting system, its advantages and limitations.

Part B: Charge Particle Accelerators

Linear accelerator (LINAC) - Pelletron-construction and principle of operation, its advantages and limitations.

Part C: Cyclic Accelerators

Cyclotron - Construction and principle of operation, its advantages and limitations, Concept of synchrocyclotron.

Unit VI: Nuclear Decay **Lectures 8**

Essential condition of beta decays, beta ray spectrum, apparent violation of energy momentum conservation rules in beta decay, Pauli's neutrino hypothesis, experimental discovery of neutrino - Cowan'sexperiment, Fermi's theory of beta decay, Kurie plot and concept of massive neutrino, 2s and 0*s* double beta decays.

Unit VII: Elementary Particles **Lectures 5**

Classifications of elementary particles and their interactions, conservation laws, symmetry principles and quantum numbers, strangeness and isospin, Gellman-Nishijima scheme, Quark model.

Suggested Readings:

- Introductory Nuclear Physics, Kenneth S Krane
- Introductory Nuclear Physics, Samuel S M Wong
- Atomic and Nuclear Physics (Vol. 2), S N Ghoshal
- Concepts of Modern Physics, Arthur Beiser
- Techniques for Nuclear and Particle Physics Experiments, W R Leo
- Nuclear reactions and structure studies, P E Hodeson
- Techniques of radiation Measurements, G F Knoll

Course designed by –

i) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
ii) Dr. Rajib Kr. Basumatary, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Prof. Manoj Kr. Sarma, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester:Eight
Course Name: Quantum Mechanics II
Course Code: PHY-MJ-08014
Credit: 4 (3 Theory + 1 Tutorial+ 0 Practical)

Course Objectives:

The objective of this course is to introduce students to the laws of Physics in the context of the micro world. The students will be able to understand the underlying mechanics of atomic and sub-atomic phenomena. This course delivers the essence of wave mechanics and matrix formulations of quantum mechanics, concept of identical particles, symmetry, and approximation methods.

Course Outcomes:

- The objective of this course is to introduce students to the laws of Physics in the context of the micro world.
- The students will be able to understand the underlying mechanics of atomic and sub-atomic phenomena.
- This course delivers the essence of wave mechanics and matrix formulations of quantum mechanics, concept of identical particles, symmetry, and approximation methods.

Title of the course	Quantum Mechanics II
Course code	PHY-MJ-08014
Total Credit	4 (3 Theory+ 1 Tutorial+ 0 Practical)
Contact hours	45 (L)+ 15 (T)+ 0 (P)
Distribution of Marks	Internal Assessment: 40 End Semester Examination: Theory=60; Practical=0

Course Summary:

<table>
<tr><th>Unit</th><th>Topic</th><th>Lecture (hours)</th><th>Tutorial (hours)</th><th>Practical (hours)</th><th>Total (hours)</th></tr>
<tr><td>I</td><td>Basic Principles of Quantum Mechanics</td><td>15</td><td rowspan="4">15</td><td rowspan="4">0</td><td rowspan="4">60</td></tr>
<tr><td>II</td><td>Identical Particles</td><td>8</td></tr>
<tr><td>III</td><td>Symmetry, Invariance Principle, and Conservation</td><td>7</td></tr>
<tr><td>IV</td><td>Approximation Methods in Quantum Mechanics</td><td>15</td></tr>
</table>

DETAILED SYLLABUS
Quantum Mechanics II

Theory (Credit 3) + Tutorial (Credit 1)

Unit I: Basic Principles of Quantum Mechanics **Lectures 15**

Essence of wave mechanics, physical interpretation of wave function, central potential, spherical harmonics and complete wave function (H-atom), orbital angular momentum. Particles at potential steps and potential barriers. Quantum wells and bound states. Matrix formulation of quantum mechanics, Bra and Ket vectors and applications, orthonormal and completeness conditions, simultaneous eigen states, expectation values, linear harmonic oscillator in operator method. Heisenberg's uncertainty principle in matrix mechanics. Heisenberg's equation of motion and physical equivalence of Schrödinger & Heisenberg picture.

Unit II: Identical Particles **Lectures 8**

Indistinguishability, combinations of wave functions for a system of particles, symmetric and antisymmetric wave functions, spin-statistics connection, evolution of quantum statistics, exchange symmetry and exchange degeneracy.

Unit III: Symmetry, Invariance Principle, and Conservation **Lectures 7**

Space and time translations, rotational invariance under infinitesimal and finite rotations. Angular momentum operators, ladder operators, addition of angular momenta - Clebsch-Gordan coefficients.

Unit IV: Approximation Methods in Quantum Mechanics **Lectures 15**

Time independent perturbation theory, Stark and Zeeman effects, variational method and its applications, WKB approximation, time dependent perturbation theory, transition to continuum states, Fermi's Golden rule, adiabatic and sudden approximation.

Suggested readings:

- Quantum Mechanics, S N Biswas
- Quantum Mechanics, A K Ghatak and S Lokanathan
- Introductory Quantum Mechanics, R L Liboff
- Principles of Quantum Mechanics, R Shankar
- Quantum Mechanics: concepts and applications, N Zettili

Course designed by-

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ii) Dr. Saiful Islam, Department of Physics, Darrang College (Autonomous) Tezpur, Assam.
iii) Dr. Dibya Jyoti Sivananda Department of Physics, Darrang College (Autonomous) Tezpur, Assam.

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Subject: Physics (Major)
Semester: Eight
Course Name: Advanced Condensed Matter Physics
Course Code: PHY-MJ-08024
Credit : 4 (Theory)

Course Objectives:

To provide the elementary idea about crystal structure, bonding and lattice dynamics in solids. To make the students understand the concepts of transport properties, dielectric properties, ferroelectric properties and magnetic properties in solids. To familiarise the students with synthesis techniques and the characterization methods.

Course Outcome:

On successful completion of the course, students will be able to acquire the basic knowledge of crystal structure, bonding in solids and have an elementary idea of lattice dynamics in materials. Students will also learn about dielectric, ferroelectric and magnetic properties of solids. They will also acquire knowledge on nanomaterials, thin film synthesis and characterization.

Title of the course	Advanced Condensed Matter Physics
Course code	PHY-MJ-08024
Total Credit	4 (Theory)
Contact hours	53(L) + 7(T) + 0(P)
Distribution of Marks	Internal Assessment: 40 End Semester Examination: Theory=60; Practical=0

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Crystal Physics	9	7	0	60
II	Lattice Dynamics	10			
III	Diffusion and Phase Transformation	9			
IV	Neutron Scattering	5			
V	Nanophysics	5			
VI	Material Synthesis Techniques	9			
VII	Characterization Techniques	6			

DETAILED SYLLABUS
Advanced Condensed Matter Physics

<u>Theory (Credit 4)</u>

Unit I: Crystal Physics **Lectures 9**

Typical crystal structures: Simple (sc) cubic, body centered (bcc) cubic and face centered (fcc), cubic structures, Hexagonal closed packed (hcp), Diamond and Zinc blende (ZnS) closed packed structures, packing factors, NaCl, CsCl and cubic perovskite and wurtzite structures. Structure of solids: linear and planar density, ligancy, packing efficiency, closed pack planes and directions, voids. Crystal imperfections: point imperfections (vacancies and interstitials), Frenkel and Schottky defects, colour centres, linear and edge dislocations, Bergers' vector, grain boundary, grain growth and surface energy calculation.

Unit II: Lattice Dynamics **Lectures 10**

Reciprocal lattice, Ewald construction, Diffraction of X-rays by Crystals, Bragg's Law, Atomic and Geometrical Factor, atomic form factor, structure factor and Debye-Waller factor, Experimental methods: Laue method, Rotating crystal method, Powder method Brillouin Zones. Lattice vibration in solids: Enumeration of modes, monoatomic linear chain, infinite and finite boundary conditions, dispersion relation, diatomic chain, acoustical and optical modes, quantization of lattice vibrations (phonons)

Unit III: Diffusion and Phase Transformation **Lectures 9**

Diffusion: Fick's first and second laws, thermal diffusion, Phase and phase transformation: Melting point of crystalline and amorphous solids, degrees of freedom, phase rule, binary alloys, nucleation and phase transformation, Elastic properties, Young, bulk and rigidity moduli, yield stress, Poisson's ratio, compressibility, creep and fatigue, plasticity.

Unit IV: Neutron Scattering **Lectures 5**

Inelastic neutron scattering, analysis of data by generalized Ewald construction, dispersion relations, frequency distribution function, thermal conductivity of insulators, Normal and umklapp processes, thermo-luminescence

Unit V: Nanophysics **Lectures 5**

Nanoscale systems: Length scales, 1D, 2D and 3D nanostructures (nanodots, nanowires, nanorods, thin films,), Band structure and density of states of materials at nanoscale, Size effects in nano systems, Quantum confinement

Unit VI: Material Synthesis Techniques **Lectures 9**

Top down and Bottom up approach, Photolithography. Ball milling, Gas phase condensation, Vacuum deposition, Thin Film deposition, Physical vapour deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition, Chemical vapour deposition

(CVD), Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods, MBE (introduction only).

Unit VII: Characterization Techniques **Lectures 6**

X-Ray Diffraction, Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunnelling Microscopy

Suggested Readings:

- Introduction to Solid State Physics, C Kittel
- Solid State Physics, A J Dekker.
- Introductory Solid State Physics, H P Myers.
- Solid State Physics, N W Ashcroft and N D Mermin
- Condensed Matter Physics, M. Mardar
- Materials Science and Engineering, W.D. Callister
- Introduction to Solids, L. V. Azaroff.
- Introduction to Nanotechnology, C.P. Poole, Jr. Frank J. Owens
- Nanotechnology: Principles & Practices, S.K. Kulkarni
- Introduction to Nanoscience and Technology, K.K. Chattopadhyay and A. N. Banerjee

Course designed by-

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Subject: Physics (Major)
Semester: Eight
Course Name: Electromagnetic Theory-II
Course Code: PHY-MJ-08034
Credit: 4 (3 Theory + 1 Tutorial)

Course Objectives:

The course objective of Electromagnetic Theory-II is to provide students with an advanced understanding of electromagnetic fields and wave propagation as well as the fundamental concepts of scattering and radiation phenomena. The course aims to build proficiency in solving boundary-value problems, applying gauge transformations, and analyzing wave behaviour in different media including waveguides. It also introduces students to the motion of charged particles in electromagnetic fields and prepares them to grasp the covariant formulation of Maxwell's equations and its significance in modern physics.

Course Outcomes:

Upon successful completion of the course, students will be able to analyze complex electromagnetic wave interactions such as scattering and reflection, understand radiation mechanisms from charged particles, and describe the behaviour of plasmas and ionized gases. They will gain skills in applying mathematical techniques to solve electrostatic and electromagnetic problems, and comprehend foundational plasma concepts relevant to magnetic confinement and magneto-hydrodynamics. This knowledge will enable them to investigate advanced topics in electromagnetism and prepare for research or professional work in physics and related disciplines.

Title of the course	Electromagnetic Theory-II
Course code	PHY-MJ-08034
Total Credit	4 (3 Theory+ 1 Tutorial)
Contact hours	45 (L)+ 15 (T)+ 0 (P)
Distribution of Marks	Internal Assessment: 40 End Semester Examination: Theory=60; Practical=0

Course Summary:

Unit	Topic	Lecture (hours)	Tutorial (hours)	Practical (hours)	Total (hours)
I	Boundary-value Problems in Electrostatics	4	15	0	60
II	Gauge Transformations	3			
III	Propagation of Electromagnetic Waves	8			
IV	Scattering of Electromagnetic Waves	6			
V	Motion of Charged Particles	4			
VI	Radiation Fields	8			
VII	Covariant Form of Maxwell's Equations	4			
VIII	Basics of Plasma	8			

DETAILED SYLLABUS
Electromagnetic Theory-II

Theory (Credit 3) + Tutorial (Credit 1)

Unit I: Boundary-value Problems in Electrostatics **Lectures 4**

Electrostatic boundary value problems, solution of problems involving Laplace's and Poisson's equations in spherical, cylindrical and Cartesian coordinates, use of Green's function approximation.

Unit II: Gauge Transformations **Lectures 3**

Review of Maxwell's equations, electromagnetic potentials, gauge transformation, Lorentz and Coulomb gauge, gauge invariance.

Unit III: Propagation of Electromagnetic Waves **Lectures 8**

Propagation of electromagnetic waves in free space, non-conducting and conducting media, reflection and transmission at the boundary of two non-conducting media, reflection from a metal surface, propagation of electromagnetic waves in bounded media, wave guides.

Unit IV: Scattering of Electromagnetic Waves **Lectures 6**

Scattering of electromagnetic waves due to free electrons, Thomson scattering, scattering from bound electrons, Rayleigh scattering and resonance fluorescence, dispersion – normal and anomalous.

Unit V: Motion of Charged Particles **Lectures 4**

Non-relativistic motion of a charged particle in uniform constant fields and slowly varying field; gradient drift, magnetic mirror.

Unit VI: Radiation Fields **Lectures 8**

Retarded potential, radiation from oscillatory dipole, radiation fields, radiation from a point charge in motion, Lienard-Wiechart potential, fields of a point charge in motion, power radiated by a point charge, Larmor formula, Bremsstrahlung.

Unit VII: Covariant Form of Maxwell's Equations **Lectures 4**

Four dimensional Lorentz transformation, covariance of Maxwell's equations, electromagnetic field tensor.

Unit VIII: Basics of Plasma **Lectures 8**

Propagation of plane electromagnetic waves in low pressure ionised gases, conductivity of ionised gas, plasma frequency, Debye screening length, propagation of transverse waves in a perfectly conducting fluid embedded in a magnetic field (frozen-in field), and MHD, Alfvén waves, basic idea of plasma confinement.

<u>Suggested Readings:</u>

- Introduction to Electrodynamics, D. J. Griffiths.
- Electromagnetics, B. B. Laud, New Age International Publishers.
- Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
- Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- Electromagnetic Field Theory, R. S. Kshetrimayun, 2012, McGraw Hill.
- Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.

<u>Course designed by-</u>

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Subject: Physics (Major)
Semester: Eight
Course Name: Dissertation
Course Code: PHY-MJ-08044
Credit: 4

Course Objective:

To provide students with a structured opportunity to engage in independent, supervised research that synthesizes and applies the concepts, methods and skills acquired throughout the FYUGP curriculum. It aims to develop students' ability to identify and formulate a research problem, design and execute an appropriate theoretical, experimental or computational study, and critically analyse and interpret data in accordance with ethical and professional standards in physics. The course further seeks to enhance scientific writing and presentation skills by guiding students to produce a well-organized dissertation and defend their work before an academic panel, thereby nurturing research aptitude and preparing them for postgraduate studies and careers in physics and allied fields.

Course Outcome:

On successful completion of the Research Project, the student will be able to

- Formulate a well-defined research problem in a focused area of physics, based on a critical review of current literature and identification of knowledge gaps.
- Apply appropriate theoretical, experimental or computational methods to design and implement a feasible research plan within given time and resource constraints.
- Collect, analyse and interpret quantitative and/or qualitative data using suitable analytical, numerical and statistical tools, and draw logically consistent, evidence-based conclusions.
- Adhere to research ethics, including proper citation, avoidance of plagiarism, responsible data handling, and safe laboratory/field practices.
- Communicate research processes and outcomes effectively through a structured dissertation and oral presentation/defence, using clear scientific language, visuals and appropriate referencing style.

- Reflect and work independently as well as collaboratively (where applicable), demonstrating time management, self-directed learning and openness to feedback from supervisor and examiners.

Title of the course	Dissertation
Course code	PHY-MJ-08044
Total Credit	4
Assessment	Total Marks: 100 Internal Assessment, Dissertation Defense cum Viva Voce