SIDO KANHU MURMU UNIVERSITY, DUMKA

(A State University recognized under Section 2(f) & 12(B) of the UGC Act, 1956)

SYLLABUS

OF

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

FOR

PHYSICS

(HONOURS/RESEARCH/PG DIPLOMA)

In accordance with the

Implementation of the FYUGP under the State Universities of Jharkhand Regulations, 2024

Implemented from the Academic Session 2025-2029 onwards

Board of Studies Meeting Proceedings

A meeting of the Board of Studies for the revision and finalization of the **PHYSICS (HONS/RESEARCH/PG DIPLOMA)** syllabus for the Four-Year Undergraduate Programme (FYUGP), in accordance with the Implementation of FYUGP under the State Universities of Jharkhand Regulations, 2024, was convened on **15/10/2025.**

The following members of the Board of Studies were present in this meeting. The committee unanimously accepted and recommended the syllabi, incorporating minor modifications suggested by the committee members.

Members of the Board of Studies:

S. NO.	MEMBERS	SIGNATURE
1.	**Dr. Rajesh Kumar Yadav,** Head, University Department of Physics	
2.	**Prof. Kamal Prasad,** Professor and Head, University Department of Physics, TMBU Bhagalpur	
3.	**Dr. R .R. Sinha, Assistant Professor,** University Department of Physics	
4.	**Dr. R. S. Kumar, Assistant Professor,** S. P. College, Dumka	
5.	**Dr. Indrajeet Kumar, Assistant Professor,** S. P. College, Dumka	
6.	**Mr. Rajesh Kumar, Assistant Professor,** Model College, Dumka	
7.	**Dr. Mahendra Goray, Need Based Assistant Professor,** S. P. College, Dumka	
8.	**Dr. Dharmendra Yadav, Need Based Assistant Professor,** B. S. K. College, Berherwa	
9.	**Dr. Jitendra Saha, Need Based Assistant Professor,** Sahibganj College, Sahibganj	
10.	**Dr. Shyam Sundar Mahato, Need Based Assistant Professor,** RDBM College, Deoghar	

Dr. Rajesh Kumar Yadav
(Chairperson)

Semester-wise Subject Combination for B.Sc. (PHYSICS)

Semester	Course Category	Code	Papers	Credits
First Semester	Major	MJ-1	Mechanics and Properties of Matter	4
	Associated Core/Associated Vocational	AC-1A	Select any one subject from the Associated Core Table with the guidance of the Class Teacher	4
	Multidisciplinary Course	MDC-1	**Choose any one of the following:** • Mathematical and Computational Thinking Analysis • Gender Studies • Goods and Services Tax (GST) • Pollution Control and Waste Management	3
	Ability Enhancement Course	AEC-1	Hindi (Compulsory)	2
	Skills Enhancement Course	SEC-1	Introduction to Computer and IT (Compulsory)	2
	Value Added Course	VAC-1	Understanding India (Compulsory)	3
	Indian Knowledge System	IKS-I	Indian Knowledge System (Compulsory)	2
Second Semester	Major	MJ-2	Mathematical Physics-I	4
	Associated Core/Associated Vocational	AC-2B	Select any one subject either from the Associated Core subjects not studied in Semester-I or from the Associated Vocational subjects, with the guidance of the Class Teacher	4
	Multidisciplinary	MDC-2	**Choose any one of the following:** • Nutrition and Health education • Digital Marketing • Introduction to Indian Values and Ethics • Santhal Tribes and Culture	3
	Ability Enhancement	AEC-2	English (Compulsory)	2
	Skills Enhancement	SEC-2	Digital Communication and Data Management (Compulsory)	3
	Value Added Course	VAC-2	Environmental Studies (Compulsory)	2
	Indian Knowledge System	IKS-2	Social Awareness (Compulsory)	2
Third Semester	Major	MJ-3	Electricity and Magnetism	4
		MJ-4	Waves and Optics	4
	Elective Course	ELC-1A	Elective Paper-1 from the Chosen Associated Core Subject in Semester I	4
	Multidisciplinary	MDC-3	**Choose any one of the following:** • Indian Philosophy • Indian Cultural Studies • Kautilya's Arthashastra • Vedic Mathematics	3
	Ability Enhancement	AEC-3	**Select One Language Course:** Students must choose **one** of the following languages: **Hindi, English, Bangla, Sanskrit, Urdu, Santali, Persian, or Maithili** **Note:** Students are required to study **Paper-I** of the language they choose.	2
	Skills Enhancement	SEC-3	Computer Software, Programming and AI(Compulsory)	3
Fourth Semester	Major	MJ-5	Indian knowledge system: Physics in Ancient India	4
		MJ-6	Heat and Thermodynamics	4
		MJ-7	Semiconductor Devices	4

	Elective Course	ELC-1B	Elective Paper-1 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4
	Ability Enhancement	AEC-4	Paper-2 of Selected Language course in Semester-III	2
	Value Added Course	VAC-3	Health& Wellness, Yoga Education, Sports & Fitness (Compulsory)	2
Fifth Semester	Major	MJ-8	Electromagnetic Theory	4
		MJ-9	Numerical Techniques and Programming	4
		MJ-10	Classical Mechanics	4
		MJ-11	Quantum Mechanics-I	4
	Elective Course	ELC-2A	Elective Paper-2 from the Chosen Associated Core Subject in Semester I	4
Sixth Semester	Major	MJ-12	Modern Physics	4
		MJ-13	Statistical Mechanics	4
		MJ-14	Digital Electronics and Applications	4
		MJ-15	Solid State Physics	4
	Elective Course	ELC-2B	Elective Paper-2 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

- In the fourth year, students have two pathways: they can either complete their graduation with **Honours**, or **Honours with Research**.
- Those who wish to graduate with **Honours only** must follow **Table-A**, while those opting for **Honours with Research** must follow **Table-B**.

TABLE-A FOR HONOURS ONLY
FOURTH YEAR

Seventh Semester	Major	MJ-16	Electrodynamics and Plasma Physics	4
		MJ-17	Mathematical Physics-II	4
		MJ-18	Quantum Mechanics-II	4
	Advance Major	AMJ-1	Advanced Quantum Mechanics	4
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4
Eighth Semester	Major	MJ-19	Nuclear and Particle Physics	4
		MJ-20	GROUP DISCUSSION AND DISSERTATION	
	Advance Major	AMJ-2	Classical Dynamics	4
		AMJ-3	Advanced Statistical Mechanics	4
	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

TABLE-B FOR HONS WITH RESEARCH
FOURTH YEAR

Seventh Semester	Major	MJ-16	Electrodynamics and Plasma Physics	4
		MJ-17	Mathematical Physics-II	4
		MJ-18	Quantum Mechanics-II	4
	Research Methodology	RM-1	Research Methodology	4
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4
Eighth Semester	Major	MJ-19	Nuclear and Particle Physics	4
		MJ-20	Dissertation	4
	Research Project/ Dissertation	RC-2	----------	8
	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

Compulsory Summer Internship:

1. ***If a student exits after Semester II, IV, or VI:***

To receive a Certificate/Diploma/Bachelor's Degree, students must complete a summer internship/project/dissertation worth 4 credits. This should be done during the summer break of any semester within the first three years.

Note: The Certificate/Diploma/Bachelor's Degree will not be awarded without completing this internship.

2. ***If a student exits after Semester VIII:***

Under the National Education Policy (NEP), all students must complete a 4-credit summer internship to get a Bachelor's Hons/Hons with Research/P.G. Diploma Degree.

There are two ways to complete this requirement:

a. Two internships of 4 weeks each (2 credits each), or

b. One internship of 8 weeks (4 credits total)

The college will help arrange the internship, and students can complete it any time between Semester 1 and Semester 6 Summer Vacation.

Note: The Bachelor (Hons)/Hons with Research, or P.G. Diploma will not be awarded without completing the internship.

INSTRUCTIONS FOR QUESTION SETTER

1. **Semester Internal Examination Question Pattern** (15 Marks)

The **Semester Internal Examination (SIE)** will carry a total of **15 marks**, which includes **10 marks for the internal test** and **5 marks for class attendance**. The question paper will have **two groups**.

Group A will have: **Question 1:** Five very short answer questions (1 mark each, total 5 marks)

Group B will have: Two descriptive-type questions of 5 marks each, out of which students must answer **any one** (total 5 marks) the remaining **5 marks** will be based on **class attendance**, as per the following:

- Up to 45% attendance: 1 mark
- 46% to 54%: 2 marks
- 55% to 64%: 3 marks
- 65% to 74%: 4 marks
- 75% and above: 5 marks

2. **End Semester University External Examination Question Pattern**(60 Marks)

The **End Semester Examination (ESE)** will be of **60 marks** and will also have **two groups**.

Group A (Compulsory) will include: **Question 1:** Five very short answer questions (1 mark each, total 5 marks)

Questions 2 and 3: Two short answer questions (5 marks each, total 10 marks) **Group B** will contain **five descriptive-type questions** of **15 marks each**, out of which students must answer **any three** (total 45 marks)

Note: Questions may have sub-parts if needed in the theory examination.

3. **End Semester University Practical Examination Question Pattern** (25 Marks)

The **End Semester Practical Examination (ESE)** will be of **6 hours duration**. The total marks and evaluation should be done as per the following guidelines:

- **Experiment/Activity performed during the exam** – 15 marks
- **Practical record notebook** – 5 marks
- **Viva-voce (oral questions)** – 5 marks

Students must score **at least 10 marks** to pass the practical examination.

PROMOTION CRITERIA

- All students will be promoted in odd Semesters (I, III, V & VII).
- To get a promotion from Semester II to Semester III, from Semester IV to Semester V, and from Semester VI to Semester VII a student has to procure a minimum of 4 CGPA.
- However, it will be necessary to obtain a minimum credit (4) to pass in each of the subjects individually before completion of the course.

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

The passing in a subject will be based on the combined marks obtained in both the internal and external examinations of the semester. However, the student must pass the theory and practical examinations separately.

Internal Semester Examination: 10 Marks

F.M.=10	**Subject/Code** **Time= 1 Hrs.**	**Exam Year**

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A [5x1=5]

1.
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....

Group B

2. .... [5]
3. .... [5]

Note: There may be subdivisions in each question asked in Theory Examination.

End Semester Examination: 60 Marks

F.M.=60	**Subject/Code** **Time= 3 Hrs.**	**Exam Year**

vi. **Group A** carries very short answer type **compulsory** questions.
vii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
viii. Answer in your own words as far as practicable.
ix. Answer all sub parts of a question at one place.
x. Numbers in right indicate full marks of the question.

Group A [5x1=5]

1.
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]
3. .... [5]

Group B

4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER - I

COURSE: MAJOR – 1(MJ-1) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: MECHANICS AND PROPERTIES OF MATTER **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

This course aims to enable the students to acquire the key concepts of the general properties of matter, the motion of a particle under central force field, oscillations and special theory of relativity.

COURSE OUTCOMES:

1. Learn about the behavior of physical bodies around us in daily life.
2. Understand the dynamics of planetary motion.
3. Build a foundation of various applied field in science and technology.
4. Develop the analytical thinking on Mechanics in order to understand the response of the classical systems to external forces.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

General Properties of Matter (15 Lectures): Hooke's law. Stress-strain diagram, Elastic moduli, Poisson's Ratio: Expression for Poisson's ratio in terms of elastic constants. Relation between Elastic constants. Kinematics of Moving Fluids: Viscous fluid, Poiseuille's Equation for Flow of a Liquid through a Capillary Tube with correction, Flow of compressible fluid through a capillary tube, Rankine's methods for measurement of viscosity of gas. Surface tension and surface energy, angle of contact, Expression for excess pressure, Principle of virtual work, Ripples and Gravity waves.

UNIT-II:

Central Force Motion and Oscillation (15 Lectures): Motion of a particle under a central force field. Conservation of angular momentum. Kepler's Laws of planetary motion and their derivations. Satellite in circular orbit and applications, Centrifugal force. Simple Harmonic Oscillations (SHM).Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Examples of Physical Systems Executing SHM: Simple Pendulum, Compound Pendulum, Torsional Pendulum, LC-Circuit. Damped oscillation. Forced oscillations: Resonance, sharpness of resonance, power dissipation and Quality Factor.

UNIT-III:

Special Theory of Relativity (15 Lectures): Inertial and Non-inertial frames. Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Lorentz contraction. Time dilation. Simultaneity and order of events. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler Effect.

SUGGESTED READINGS:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics by D. S. Mathur, S. Chand.
3. Physics, Resnick, Halliday and Walker, 2008, Wiley.
4. Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
5. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
6. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. To determine the value of g using simple Pendulum
2. To determine the value of g using Bar Pendulum.
3. To determine the value of g using Kater's Pendulum.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the elastic Constants of a wire by Searle's method.
6. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

SUGGESTED READINGS:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - II

COURSE: MAJOR – 2(MJ-2) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: MATHEMATICAL PHYSICS-I **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

This course aims to enable the students to acquire the key concepts of the general properties of matter, the motion of a particle under central force field, oscillations and special theory of relativity.

COURSE OUTCOMES:

1. Learn about the behavior of physical bodies around us in daily life.
2. Understand the dynamics of planetary motion.
3. Build a foundation of various applied field in science and technology.
4. Develop the analytical thinking on Mechanics in order to understand the response of the classical systems to external forces.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Vector Calculus (15 Lectures): Scalar and Vector fields, Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field and their physical interpretation. Line, surface and volume integrals. Gauss' divergence theorem, Green's and Stokes Theorems and their applications. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

UNIT-II:

Differential Equation (15 Lectures): First order differential Equations, homogeneous, non-homogeneous, exact and inexact differential equations and Integrating Factors. Homogeneous Equations with constant coefficients. Cauchy-Euler differential equation and simultaneous differential equations of First and Second order. Solutions to partial differential equations (2 or 3 independent variables) using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of wave equation for vibrational modes of a stretched string, rectangular and circular membranes. Solution of 1D heat flow equation. (Wave/Heat equation not to be derived).

UNIT-III:

Complex Analysis (15 Lectures): Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De-Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Equations. Examples of analytic functions. Singularities: poles, removable singularity, essential singularity, branch points, branch cut. Integration of a function of a complex variable. Cauchy-Goursat Theorem, Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application of Contour Integration in solving Definite Integrals.

SUGGESTED READINGS:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Academic Press/Elsevier.
2. Mathematical Physics, H. K. Dass and Rama Verma, S. Chand & Company Pvt. Ltd.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
4. Mathematical Methods for Physicis & Engineers, K.F. Riley, M.P. Hobson, S.J. Bence, 3rd Ed., 2006, Cambridge University Press.
5. Mathematical physics by B.S. Rajput, A Pragati Edition.
6. Advanced Methods of Mathematical Physics by R.S. Kaushal and D. Parashar, Narosa Publishing House, New Delhi.
7. Mathematical Physics by B. D. Gupta, Vikash Publishing House Pvt. Ltd.

PART ‘B’

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Measurements of length (or diameter) using Vernier Caliper.
2. Measurement of Thickness using Screw Gauge and Travelling Microscope.

3. Measurement of thickness of thin transparent plates using Spherometer.
4. Determination of radius of curvature using Spherometer.
5. Measurement of volume and density of (A) a solid cylinder and (B) hollow cylinder (pipe), using Vernier calipers and Screw Gauge.
6. Use of a multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

SUGGESTED READINGS:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal. Publications.

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SEMESTER - III

COURSE: MAJOR – 3 (MJ-3) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ELECTRICITY AND MAGNETISM **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objectives:

The course aims to develop a comprehensive understanding of electrostatics, dielectric and magnetic properties of matter, electromagnetic induction, and AC electrical circuits, emphasizing fundamental principles, mathematical formulations, and practical applications. It also aims to build problem-solving skills and a strong theoretical foundation for advanced studies in electromagnetism and applied physics.

Learning Outcomes:

1. Apply Gauss's law and solve Laplace's and Poisson's equations to analyze electric fields and potentials.
2. Understand conductor behavior, capacitance, and apply the method of images.
3. Examine dielectric and magnetic properties, including polarization, magnetization, and hysteresis.
4. Explain electromagnetic induction, and calculate self/mutual inductance and energy stored in magnetic fields.
5. Solve AC circuit problems using impedance, and analyze devices like bridges and transformers.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Electric Field and Electric Potential (15 Lectures): Electric flux, Gauss' law in integral and differential form and its applications, Conservative nature of Electrostatic Field, Laplace's and Poisson equations, The Uniqueness Theorem, Electric field and Potential due to electric dipole and quadrupole, Conductors in an electrostatic Field, Surface charge and force on a conductor, Capacitance of a system of charged conductors, Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

UNIT-II:

Dielectric and Magnetic Properties of Matter (15 Lectures): Electric Field (E) in matter. Polarization (P) and Polarizability, Electrical susceptibility and Dielectric constant, Displacement vector D, Relations between E, P and D, Clausius-Mossotti equation, Gauss' Law in dielectrics, Magnetization vector (M), Magnetic field Intensity (H), Magnetic Susceptibility and permeability, Relation between B, H and M, B-H curve and hysteresis, Properties of magnetic materials- Dia, Para and Ferromagnetism, Langevin's theory, Measurement of susceptibility by Quincke's Method.

UNIT-III:

Electromagnetic Induction and Electrical Circuits (15 Lectures): Faraday's Law, Lenz's Law, Self-Inductance and Mutual Inductance, Reciprocity Theorem, Energy stored in a Magnetic Field, Charge Conservation and Displacement current, Torque on a current Loop, Ballistic Galvanometer: Current and Charge Sensitivity, Electromagnetic damping, Logarithmic damping. AC Circuits: Kirchhoff's laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width, Parallel LCR Circuit, Anderson's bridge, De-Sauty bridge and Carey Foster bridge, Equivalent circuit and vector diagram, Transformer, Losses in transformer.

SUGGESTED READINGS:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
2. Introduction to Electrodynamics, D.J. Griffiths, Cambridge University Press.
3. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
4. Electricity and Magnetism by K. K. Tewary, S Chand.
5. Electricity and Magnetism by D. C. Tayal, Himalaya Publishing House
6. Concepts of Physics-Classical Electromagnetism by H. C. Verma, BhartiBhawan.
7. Fundamentals of Magnetism and Electricity by D. N. Vasudeva, S. Chand.
8. Electrical circuits by M. R. Speigel, Schaum Series.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To compare capacitances using De'Sauty's bridge.
5. To determine self-inductance of a coil by Anderson's bridge.
6. To study 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.

SUGGESTED READINGS:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
2. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
3. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011, KitabMahal.
4. Numerical Methods, E Balagurusamy, McGraw Hill Education.

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SEMESTER - III

COURSE: MAJOR – 4(MJ-4) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: Waves and Optics **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to provide students with a comprehensive understanding of wave phenomena in physics, including wave basics, wave optics, interference, diffraction, and polarization.

Learning Outcomes:

1. Understand the properties and behaviors of plane and spherical waves, longitudinal and transverse waves, and their mathematical representations.
2. Apply the wave equation and principles of energy transport to analyze wave propagation and intensity.
3. Analyze and interpret phenomena such as interference fringes, diffraction patterns, and polarization effects using theoretical models and experimental techniques.
4. Demonstrate proficiency in solving problems related to standing waves, interference, and diffraction in various mediums.
5. Explain the electromagnetic nature of light, including the laws of reflection and refraction, and apply them to optical systems such as lenses, mirrors, and interferometers.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Wave Basics (15 Lectures): Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Linearity and Superposition Principle, Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats), Graphical and Analytical Methods, Lissajous Figures and their uses, : 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, Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle, Temporal and Spatial Coherence, Fermat's Principle, Lens and Mirror formula, Laws of reflection and refraction, Cardinal points.

UNIT-II:

Interference and Diffraction (20 Lectures): Interference: Division of amplitude and wavefront, Interference in Thin Films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness (Fizeau Fringes), Newton's Rings: Measurement of wavelength, Measurement of refractive index. Michelson Interferometer, Michelson-Morley experiment and its failure, Determination of Wavelength, Wavelength Difference, Refractive Index, Visibility of Fringes, Fabry-Perot Interferometer.

Diffraction: Fresnel's Assumptions, Fresnel's half-Period Zones for Plane Wave, Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral and its applications, Fresnel diffraction pattern of a straight edge, a slit and a wire. Fraunhofer Diffraction**:** Single slit diffraction, double slit diffraction, Circular aperture, Multiple slits Resolving Power of a telescope, Resolving power of grating, Use of grating to produce monochromatic light.

UNIT-III:

Polarization (10 Lectures): Polarization by reflection, Brewster's law, Double refraction, Nicol prism, Ordinary& extraordinary refractive indices, Retardation plate: $\lambda/2$ and $\lambda/4$ plates, Babinet compensator, Description of Linear, Circular and Elliptical Polarization, Production and detection of plane, circular, and elliptically polarized light. Optical activity.

SUGGESTED READINGS:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Optics by B. K. Mathur.

PART ‘B’

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Determine refractive index of the material of a prism using sodium source.
2. Determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
3. Determine the wavelength of sodium source using Michelson’s interferometer.
4. Determine the wavelength of sodium light using Newton’s Rings.
5. Determine the radius of curvature of a plano-convex lens by using Newton's rings.
6. Determine the wavelength of (1) Na-source and (2) spectral lines of Hg-source using plane diffraction grating.

SUGGESTED READINGS:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - IV

COURSE: MAJOR – 5 (MJ-5) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: INDIAN KNOWLEDGE SYSTEM: PHYSICS IN ANCIENT INDIA **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

Analyze Vaisheshika, Nyaya, Saṃkhya, and Vedanta frameworks for physical concepts. Critically evaluate ancient Indian theories of matter, motion, cosmology, and mathematics. Examine epistemological methods (deduction, observation, yukti/reasoning) vs. Modern scientific methodology. Assess the transmission and global impact of Indian ideas.

Learning Outcomes:

1. Understand Vaisesika and Nyaya frameworks on atomism, motion, and causation in ancient Indian physics.
2. Analyze early Indian ideas on gravity, force, and alchemy, comparing them with Newtonian concepts.
3. Explore contributions of Indian astronomy and mathematics, including planetary models and trigonometric developments.
4. Identify parallels between Indian philosophical systems and modern physics theories.
5. Recognize the contributions of Indian scientists to classical and modern physics.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Foundations of Indian Physics (20 Lectures): Vaisesika theory of atomism: parmaṇu, categories of reality, padarthas (dravya, guṇa, karma, etc.), Nyaya integration: logic, inference, epistemology (gyan mimansa) applied to natural phenomena (e.g., force, motion), Detailed study: Kaṇada's sutras, classifications of motion and physical causation. Early ideas of motion, gravity (Gurutva), and alchemy (Rasavadam), Comparative framework versus Newtonian gravity. Indian astronomy: Surya Siddhanta, Siddhanta Jyotiṣa, planetary models by Aryabhaṭa and Nilakaṇṭha Somayaji, Mathematics: Decimal place value, geometry in Śulba Sutras, Kerala school's development of trigonometry and proto calculus, Solar worship, speed of light calculations in Vedic texts, Vedic acoustics.

UNIT-II:

IKS Ideas & Modern Physics (10 Lectures): Cross cultural resonance: Correspondences between Indian philosophical ideas (e.g. Vedanta, Samkhya etc.) and modern quantum & cosmological concepts, Consciousness and cosmology: Indian models and their relevance to theories of time, Cyclic universe, Mind matter interaction.

UNIT-III:

Indian Scientists and their contributions in Physics (15 Lectures): Aryabhatta: heliocentrism, planetary motion, circumference of Earth. Bhaskaracharya: calculus, gravity, planetary models. Acharya Kanada: atomic model, classification of matter. C.V. Raman and Raman Effect, S.N. Bose and Bose-Einstein Statistics, Homi Bhabha and Indian atomic energy program, Vikram Sarabhai and ISRO, Meghnad Saha and astrophysics, Subrahmanyam Chandrasekhar and black holes, Contribution of Vashishtha Narayan Singh in in the field of relativity.

SUGGESTED READINGS:

1. Introduction to Indian Knowledge System: Concepts & Applications by B. Mahadevan, Vinayak B Rajat and Nagendra Pavana, PHI Learning Pvt Ltd. Delhi.
2. Indian Knowledge System by Sunanda M. Kangane and N. S. Jadhav,
3. Theoretical Physics and Indian Philosophy: Conceptual Coherence (Sidorova Biryukova)
4. Nyaya Vaiseṣika conceptual treatises (e.g. Narayan's overview)
5. Vaiseṣika Sutra of Kaṇāda (English trans., e.g. by Nandalal Sinha)

6. R.N. Rai (2014), Indian Physics: Outline of Early History

7. Kim Plofker (2009), Mathematics in India.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Demonstrate sound vibration using tuning forks, analyze pitch, amplitude; discuss Nada-Brahma.
2. Demonstrate a structured Nyaya-style inference (anumana) for a physical event.
3. Construct a basic Panchanga-based calendar noting tithis, nakshatras, and planetary conjunctions.
4. Analyze the famous Rigveda verse (by Sayana) estimating speed of light; compare numerically with modern values.
5. Construct altars using Pythagorean triples as described in Śulba Sūtras.
6. Predict sunrise/sunset or planet positions using simplified algorithms from Surya Siddhanta.
7. Derive sine and cosine values using Madhava's series; compare with modern Taylor expansions.
8. Construct a simple ancient Indian timekeeping device using water flow.

SUGGESTED READINGS:

1. Introduction to Indian Knowledge System: Concepts & Applications by B. Mahadevan, Vinayak B Rajat and Nagendra Pavana, PHI Learning Pvt Ltd. Delhi.

2. Indian Knowledge System by Sunanda M. Kangane and N. S. Jadhav,

3. Theoretical Physics and Indian Philosophy: Conceptual Coherence (Sidorova Biryukova)

4. NyayaVaiseṣika conceptual treatises (e.g. Narayan's overview)

5. Vaiseṣika Sutra of Kaṇāda (English trans., e.g. by Nandalal Sinha)

6. R.N. Rai (2014), Indian Physics: Outline of Early History

7. Kim Plofker (2009), Mathematics in India.

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SEMESTER - IV

COURSE: MAJOR – 6(MJ-6) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: HEAT AND THERMODYNAMICS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to provide students with a thorough understanding of the laws of thermodynamics, kinetic theory of gases, quantum theory of radiation, and statistical mechanics, enabling them to analyze and solve complex thermodynamic problems and phenomena.

Learning Outcomes:

1. Understand the fundamental principles of thermodynamics, including the zeroth, first, second, and third laws, and apply them to analyze heat and work interactions, thermodynamic processes, and entropy changes.
2. Describe the kinetic theory of gases, including Maxwell-Boltzmann distribution, mean speeds, degrees of freedom, and the law of equipartition of energy, and apply it to calculate specific heats of gases.
3. Explain the quantum theory of radiation, including Planck's law of blackbody radiation and its implications for spectral distribution, energy density, and various radiation laws.
4. Analyze statistical mechanics concepts such as macrostates, microstates, entropy, and thermodynamic probability, and apply distribution laws like Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac to describe the behavior of gases at different temperature regimes.
5. Apply theoretical principles from thermodynamics, kinetic theory, quantum theory, and statistical mechanics to solve problems related to heat, work, radiation, and gas behavior in various physical systems.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Fundamentals of Gases and Thermodynamic Variables (10 Lectures): Kinetic Theory of Gases: Maxwell-Boltzmann Law of Distribution of Velocities, Degrees of Freedom, Law of Equipartition of Energy, Specific Heats of Gases. Real Gases and Thermodynamic Properties: Behavior of Real Gases, Virial Equation, Critical Constants and Boyle Temperature, Vander-Waal's Equation of State.

UNIT-II:

Laws of Thermodynamics and Applications (20 Lectures): Zeroth and First Law of Thermodynamics, Extensive and Intensive Thermodynamic Variables, Thermodynamic Equilibrium, Concept of Work and Heat, State Functions, Internal Energy, General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. Reversible and Irreversible Processes, Conversion of Work into Heat and Heat into Work, Heat Engines, Carnot's Cycle and Efficiency, Refrigerators and Coefficient of Performance, Kelvin-Planck and Clausius Statements, Carnot's Theorem, Clausius Inequality, Applications of Second Law, Entropy and Clausius Theorem, Entropy of a perfect gas. Principle of increase of Entropy, Entropy Changes in Reversible and Irreversible processes with examples, Mixing of entropy of two ideal gases, Entropy of the Universe, Temperature-Entropy Diagrams for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

UNIT-III:

Thermodynamic Potentials and Transport Phenomena (15 Lectures): Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. First and Second Order Phase Transitions: Clausius-Clapeyron Equation and Ehrenfest Equations. Derivations and Applications of Maxwell's Relations. Maxwell's Relations: Clausius-Clapeyron Equation, Values of C_p-C_v, T-ds Equations, Joule-Kelvin Coefficient for Ideal and Van der Waal Gases. Molecular Collisions and Transport Phenomena: Mean Free Path, Collision Probability, Viscosity, Thermal Conductivity, and Diffusion in Ideal Gases, Brownian Motion and its Significance. Thermal Conductivity: Rectilinear Flow of Heat in Metal Rod, Conductivity by Periodic Flow Method.

SUGGESTED READINGS:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W. Sears and G.L. Salinger. 1988, Narosa

4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. Determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
3. Study the variation of Thermo-emf of a Thermocouple with the Difference of Temperature of its Two Junctions.
4. Calibrate a thermocouple and determination of unknown temperature.
5. Determine of the ratio of the Specific Heats of a Gas by Clement and Desorme's apparatus.
6. Determine of temperature co-efficient of the resistance of the material of a wire.

SUGGESTED READINGS:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - IV

COURSE: MAJOR – 7 (MJ-7)
PAPER NAME: SEMICONDUCTOR DEVICES
TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objectives

This course provides a fundamental understanding of semiconductor materials and devices, including diodes, transistors, and optoelectronic components. Students will learn the physical principles governing device behavior, analyze their characteristics and applications, and develop the ability to evaluate circuit performance in practical electronics and communication systems.

Learning Outcomes:

1. Understand the properties of semiconductor materials, band structures, and carrier dynamics.
2. Analyze p-n junction behavior under forward and reverse bias and apply diodes in rectification circuits.
3. Evaluate transistor operation in different configurations and understand load line and Q-point analysis.
4. Describe the working and characteristics of JFETs and MOSFETs in electronic circuits.
5. Explain the operation and applications of optoelectronic devices like LEDs, photodiodes, and solar cells.

PART ‘A’

THEORY COURSE CONTENTS:

UNIT-I:

Semiconductor Fundamentals (15 Lectures): Semiconductor Materials, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Direct and indirect bandgap semiconductors heavily doped semiconductors Carrier concentration, dependence of carrier concentration, and mobility, Electron and hole concentration equilibrium, Energy Bands: Introduction to energy bands, valence bands, conduction bands, and band gaps, Density of states, Fermi level and dependence of Fermi level on the carrier concentration. Fermi-Dirac distribution.

UNIT-II:

p-n Junction Diodes and Applications (15 Lectures): P-N Junctions Formation, Depletion region, Forward and reverse bias, Diode characteristics, Junction Capacitance, barrier formation in p-n junction, barrier potential, forward and reverse biased diode, current flow mechanism in forward and reverse biased diodes, static and dynamic resistance. Diode as rectifier, load line and Q-point, half-wave rectifier, center-tapped and bridge full-wave rectifiers, calculation of average and RMS current and voltage, voltage regulation, ripple factor and rectification efficiency, filters. Zener Diode, Zener and avalanche breakdown, Zener diode as voltage regulator. Operation and characteristics of Light-emitting diodes (LEDs), Photodiodes, Solar cells, Semiconductor lasers.

UNIT-III:

Bipolar Junction Transistors (15 Lectures): Bipolar Junction Transistors (BJTs) Basic operation n-p-n and p-n-p Transistors, Characteristics of CB, CE, and CC Configurations, Current Gains and Relations between Them, Load Line Analysis of Transistors, DC Load Line and Q-point, Physical Mechanism of Current Flow, Active, Cutoff, and Saturation Regions, Field-Effect Transistors (FETs), Junction FETs (JFETs) Operation, characteristics, parameters. Metal-Oxide-Semiconductor FETs (MOSFETs): Ideal and real MOS capacitors, threshold voltage, output and transfer characteristics.

SUGGESTED READINGS:

1. Principles of Electronics, VK Mehta and Rohit Mehta, S Chand.
2. Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.
3. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
4. Solid State Electronic Devices, B .G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning.
1. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.
5. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer.
6. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India.
7. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.
8. Hand book of electronics by Gupta and Kumar.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Study V-I characteristics of PN junction diode, and verification of diode equation.
2. Study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Estimate the energy gap of a semiconductor using a PN junction.
4. Study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. Study the frequency response of voltage gain of a RC-coupled transistor amplifier.
6. Study the output and transfer characteristics of a JFET.
7. Design a common source JFET Amplifier and study its frequency response.

SUGGESTED READINGS:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - V

COURSE: MAJOR – 8 (MJ-8) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ELECTROMAGNETIC THEORY **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	Internal Exam	Practical
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to equip students with a deep understanding of electromagnetic theory, focusing on Maxwell's equations and their applications in various media. Through theoretical lectures, students will gain proficiency in analyzing electromagnetic wave propagation, polarization phenomena, and the behavior of electromagnetic waves in different materials and structures.

Learning Outcomes:

1. Understand the derivation of Maxwell's equations and the significance of displacement current in electromagnetism.
2. Analyze the concepts of vector and scalar potentials and apply boundary conditions at interfaces between different media.
3. Describe the characteristics of plane electromagnetic waves in unbounded and bounded media.
4. Analyze polarization phenomena, including linear, circular, and elliptical polarization, and their applications in optical devices.
5. Describe the propagation of electromagnetic waves in waveguides, including planar optical waveguides, and calculate phase and group velocities of guided waves.
6. Explain the principles of optical fibers, including numerical aperture, step and graded indices, and differentiate between single and multiple mode fibers.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Maxwell Equations (10 Lectures): Derivation of Maxwell's equations, Displacement Current, Vector and Scalar Potentials, Boundary Conditions at Interface between Different Media, Wave Equations, Plane Waves in Dielectric Media, Poynting Theorem and Poynting Vector, Electromagnetic (EM) Energy Density.

UNIT-II:

EM Wave Propagation in Unbounded and Bounded Media (20 Lectures): Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law, Reflection & Transmission coefficients. Waveguides: Planar optical wave guides, Planar dielectric wave guide, Condition of continuity at interface, Phase shift on total reflection, Eigenvalue equations, Phase and group velocity of guided waves, Field energy and Power transmission. Numerical Aperture, Step and Graded Indices, Single and Multiple Mode Fibres.

UNIT-III:

Polarization of Electromagnetic Waves (15 Lectures): Description of Linear, Circular, and Elliptical Polarization, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction. Polarization by Double Refraction. Nicol Prism (construction and working), Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly, and Elliptically Polarized Light, Phase Retardation Plates: Quarter-Wave and Half-Wave Plates, Babinet Compensator and its Uses, Analysis of Polarized Light. 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.

SUGGESTED READINGS:

1. Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
3. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
4. Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
5. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

6. Optical Electronics, Ajoy Ghatak and K. Tyagrajan, Cambridge University Press.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Verification of Gauss's Law for Electric and Magnetic Fields using PhEt simulations.
2. Verify displacement current concept using an oscilloscope and capacitor with varying frequency.
3. Measure intensity of reflected and transmitted beams for different polarization angles.
4. Observe changes in polarization using an analyzer.
5. Verification of Snell's Law and Total Internal Reflection with Semi-Circular Glass Block.
6. Identification of Polarization Type (Linear, Circular, Elliptical)

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - V

COURSE: MAJOR – 9 (MJ-9) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: NUMERICAL TECHNIQUES AND PROGRAMMING **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

To equip students with the fundamentals of numerical methods and programming techniques essential for solving scientific problems. The course aims to bridge the gap between analytical mathematics and computational implementation using programming languages like Fortran, C++, or Python.

Learning Outcomes:

1. After successful completion of this course, students will be able to:
2. Analyze the accuracy and stability of numerical algorithms.
3. Solve algebraic and transcendental equations numerically.
4. Implement interpolation and numerical integration techniques.
5. Develop and execute programs for solving scientific problems using modern programming languages.
6. Apply numerical techniques for solving ordinary differential equations.
7. Write modular and efficient code using subroutines and functions.

PART 'A'

UNIT-I:

Errors, Approximation, roots of Equations and Interpolation (15 Lectures): Significant digits, round-off and truncation errors, error propagation. Direct methods: Gaussian elimination, LU decomposition. Iterative methods: Gauss-Seidel, Jacobi iteration. Eigenvalue problems: Power method, Jacobi method.

Bisection method, Newton-Raphson method, Fixed-point iteration, convergence criteria. **Interpolation**: Newton's forward and backward formulae.

UNIT-II:

Numerical Differentiation, Integration, Solution of ODE and curve fitting (15 Lectures): Trapezoidal rule, Simpson's rule, Gaussian quadrature. Solution of Ordinary Differential Equations: Euler's method, Runge-Kutta methods 4^{th} order. Least-Squares Curve Fitting, Polynomial and linear regression.

UNIT-III:

Programming Fundamentals (Python) (15 Lectures): Introduction to Programming: Flowcharts, Algorithms, Program Structure. Data Types and Arithmetic: Integer & Floating-point operations, Typecasting, Precision. Input and Output Statements: Console I/O, Formatted Output. Control Structures: Conditional Statements, Loops and Iteration. Arrays: 1D and 2D arrays, Initialization, Access, and Applications in Numerical Context. Functions and Subroutines: Definition, Parameter Passing, Return Values, Scope, Recursion Basics.

SUGGESTED READINGS:

1. Rajaraman, V. "Computer Oriented Numerical Methods", PHI Learning.
2. Chapra, S.C., and Canale, R.P. "Numerical Methods for Engineers", McGraw-Hill Education.
3. Jain, M.K., Iyengar, S.R.K., and Jain, R.K. "Numerical Methods for Scientific and Engineering Computation", New Age International.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Write a program to find roots of a nonlinear equation using the Bisection method.
2. Write a program to find roots using the Regula-Falsi method.
3. Write a program to find roots using the Newton-Raphson method.
4. Solve a system of linear equations using Gauss Elimination method.
5. Implement the Gauss-Seidel iterative method to solve a system of linear equations.
6. Compute eigenvalues of a matrix using the Power method.
7. Perform interpolation using Newton's forward difference formula.
8. Perform interpolation using Lagrange's interpolation formula.

9. Numerical differentiation using finite difference methods.
10. Numerical integration using the Trapezoidal rule and Simpson's 1/3 rule.
11. Fit a straight line to data using the least squares method.
12. Solve an ordinary differential equation using Euler's method.
13. Solve an ordinary differential equation using Runge-Kutta 4th order method.
14. Write a program to perform matrix multiplication and inverse.
15. Simulate a simple harmonic oscillator numerically using Python or C++.

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SEMESTER - V

COURSE: MAJOR – 10 (MJ-10) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: CLASSICAL MECHANICS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to provide students with a comprehensive understanding of classical mechanics, including Newtonian mechanics, Lagrangian dynamics, Hamiltonian dynamics, variational principles, canonical transformations, and special theory of relativity. Through theoretical lectures, students will develop a strong foundation in classical mechanics principles and their applications to various physical systems.

Learning Outcomes:

1. Understand the principles of classical mechanics, including Newton's laws of motion, and their application to the motion of point particles in external electric and magnetic fields.
2. Apply Lagrangian dynamics principles, including generalized coordinates, D' Alembert's Principle, and Lagrange's equations, to analyze the motion of simple mechanical systems and particles in electromagnetic fields.
3. Apply Hamiltonian dynamics principles, including generalized momentum, conservation theorems, and Hamilton's equations, to analyze the motion of particles in central force fields and electromagnetic fields.
4. Understand variational principles, including the calculus of variations, Euler-Lagrange equations, and Hamiltonian principle, and apply them to analyze mechanical systems and determine the path of least action.
5. Apply canonical transformations principles, including Legendre transformations and Poisson brackets, to analyze the transformation of coordinates and momenta in phase space.

6. Understand the postulates of the special theory of relativity, Lorentz transformations, and their consequences such as length contraction, time dilation, and addition of velocities and its realization in relativistic phenomena.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Classical Mechanics of Point Particles (10 Lectures): Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Coordinate Systems, Degrees of freedom, generalized coordinates and velocities, Principle of Virtual work, D' Alembert's Principle.

UNIT-II:

Lagrangian and Hamiltonian Dynamics (20 Lectures): Hamilton's principle and Lagrange's equations, Euler- Lagrange equations, Examples of the Euler-Lagrange equations: one- dimensional Simple Harmonic Oscillation and falling body in uniform gravity, Applications to simple systems such as coupled oscillators, Charges particle moving in an Electromagnetic field. Hamiltonian Dynamics: Generalized momentum and cyclic coordinates, Conservation Theorems, Hamiltonian's equations in Different Coordinate Systems. Examples in Hamiltonian Dynamics: 1-D and 2-D Harmonic Oscillator, Motion of a particle in a central force field, Charged particle moving in an electromagnetic field, Compound Pendulum.

UNIT-III:

Variational Principles and Canonical Transformations (15 Lectures): The Calculus of Variations and Euler-Lagrange's Equations, Hamiltonian Principle from D'Alembert's Principle, Modified Hamiltonian Principle, Lagrange's Method of Undetermined Multipliers: Simple Pendulum, Rolling hoop on an inclined Plane. Principle of Least Action. Canonical transformations and Legendre Transformations, Generating Functions, Condition for Canonical Transformations, Poisson's Brackets, Lagrange Brackets, Invariance of Poisson Bracket.

SUGGESTED READINGS:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Classical Mechanics, J. C. Uppadhyaya, Himalaya Publising House Pvt. Ltd.
3. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.

4. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.

5. The Classical Theory of Fields, L.D Landau, E. M. Lifshitz, 4th Edn., 2003, Elsevier.

6. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Determination of moment of inertia of (a) Flywheel (b) Rod (c) Thin slab.

2. Determination of moment of inertia using Torsional Pendulum.

3. Simulate and analyze the linear motion of a charged particle under a uniform electric field using Newton's second law.

4. Simulate parabolic motion; analyze displacement, velocity, and acceleration using PhET simulation.

5. Verify the conservation laws in planetary motion using real data.

   Hints: Experimental data is available from **NASA JPL HORIZON** in text (ASCII) table format.

6. Experimentally investigate the motion of a compound pendulum and derive the corresponding Hamiltonian.

7. Experimentally and theoretically investigate the normal modes of two coupled pendulum.

SUGGESTED READINGS:

1. https://phet.colorado.edu/

2. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House

3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

5. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

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SEMESTER - V

COURSE: MAJOR – 11 (MJ-11)
PAPER NAME: QUANTUM MECHANICS-I
TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to introduce students to the principles and concepts of quantum mechanics, highlighting its departure from classical mechanics and its applications in understanding the behavior of microscopic particles and systems.

Learning Outcomes:

1. Understand the inadequacy of classical mechanics in explaining certain phenomena and recognize the need for quantum mechanics.
2. Explain key concepts such as Planck's theory of blackbody radiation, the photoelectric effect, Compton scattering, and the De Broglie wavelength.
3. Analyze experimental evidence supporting wave-particle duality, including the Davisson-Germer experiment, and understand the implications of the Heisenberg uncertainty principle.
4. Describe the postulates of quantum mechanics and properties of wave functions, including normalization, linearity, superposition, and probability interpretation.
5. Solve the Schrödinger equation, both time-dependent and time-independent, for various systems including bound states in arbitrary potentials, and apply the solutions to analyze wave packet dynamics and energy eigenvalues.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Introduction to Quantum Mechanics (20 Lectures): Inadequacy of classical mechanics. Planck's theory of blackbody radiation. Photo-electric effect and Compton scattering. De- Broglie wavelength and matter waves. Davisson-Germer experiment. Group and Phase velocities and relation between them. Wave-particle duality, Heisenberg uncertainty principle. Consequences of the Uncertainty Principle- The path of an object, Zero Point Energy, The size of an atom, Existence of the electron inside the Nucleus. Postulates of Quantum Mechanics. Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Wave Function of a Free Particle. Normalization. Linearity and Superposition Principles. Eigenfunctions and Eigenvalues. Hermitian Operators. Commuting and Non-Commuting Operators. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum.

UNIT-II:

Schrodinger equation (15 Lectures): Time dependent Schrodinger equation and dynamical evolution of a quantum state. Time independent Schrodinger equation**.** Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction.

UNIT-III:

Applications of Schrodinger equation (10 Lectures) - Continuity of wavefunction, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- Free particle in a box with rigid wall, infinite and finite square well potential, One dimensional square well, Linear harmonic oscillator (1D and 3D), 3D Problems: the free particle, the box potential, Rigid rotator and Hydrogen atom (s-state) ground state.

SUGGESTED READINGS:

1. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
2. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.

3. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
6. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
7. Quantum Mechanics Concepts and Applications 2nd Edition Nouredine Zettili.
8. Quantum Mechanics: Theory and Applications by Ajoy Ghatak, S. Lokanathan.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Simulate and analyze the spectral distribution of blackbody radiation and verify Planck's radiation law.
2. Study the variation of photoelectric current with frequency and intensity of light and determine Planck's constant.
3. Demonstrate the formation of wave packets and distinguish between group and phase velocities for matter waves.
4. Study the emission spectra of Hydrogen, Neon and mercury vapors.
5. Simulate how a free particle's Gaussian wave packet evolves and spreads in time.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VI

COURSE: MAJOR – 12 (MJ-12)
PAPER NAME: MODERN PHYSICS

TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course provides a comprehensive understanding of atomic and molecular spectra, quantum mechanical models of atoms, and fundamental spectroscopic techniques. Students will learn the principles of radioactivity and nuclear processes, and gain foundational knowledge of laser physics, including laser operation mechanisms and applications in modern physics and technology.

Learning Outcomes:

1. Explain atomic models, quantum numbers, and the quantum mechanical treatment of the hydrogen atom.
2. Analyze fine and hyperfine spectral structures including spin-orbit coupling, Zeeman and Stark effects.
3. Describe molecular spectra using rigid rotor and harmonic oscillator models for various molecular types.
4. Understand radioactive decay processes, nuclear stability, and energy generation through fission and fusion.
5. Explain laser operation principles, including population inversion, types of lasers, and laser applications.

<u>PART 'A'</u>

THEORY COURSE CONTENTS:

UNIT-I:

Atomic Spectra (15 Lectures) : Rutherford experiment, Bohr's theory of hydrogen atom, de Broglie wavelength, hydrogen spectrum effect of nuclear mass, Ritz combination principle, merits & demerits of Bohr model. Schrödinger equation of hydrogen atom in spherical coordinates, separation of variables, angular equation, radial equation, principle (n), orbital (l), orbital magnetic quantum (m_l) numbers, & selection rules, vector model of atom, Stern-Gerlach experiment, electron spin, Bohr magnetron, spin magnetic quantum number (m_s), total angular momentum, addition of angular momenta, spin-orbit coupling, Larmor precession; symmetric and antisymmetric wave function, LS & JJ coupling, Zeeman effect, P-B effect, Stark effect. Electron spin, Pauli's exclusion principle, symmetric and antisymmetric wave function, atomic structure and periodic table, spin – orbit coupling, total angular momentum, atomic spectra, characteristics X-Ray spectra.

UNIT-II:

Molecular Spectra (10 Lectures): Molecular bonds, H^+ molecular ion, Hydrogen molecule, types of molecules (diatomic linear, symmetric top, asymmetric top and spherical top molecules), molecule as rigid rotor and harmonic oscillator, rotational, vibrational, and electronic spectra of diatomic molecules, brief account of spectroscopy (UV-VIS-IR spectroscopy, NMR, ESR, and Raman spectroscopy), basic concept of luminescence (introduction, excitation, and emission).

Radioactivity (10 Lectures): stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission: nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions).

UNIT-III:

Laser Physics (10 Lectures): Einstein's A and B coefficients. Metastable states. Spontaneous and stimulated emissions. Laser rate equations for two-level and three-level lasers. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Pulsed Laser and Q-switching.

SUGGESTED READINGS:

1. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education.
2. Concept of Modern Physics, Sixth Edition, Arthur Beiser, McGraw-Hill.
3. Atomic and Molecular spectra: Laser by Raj Kumar.
4. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
5. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill
6. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
7. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. To observe and measure the spectral lines of the hydrogen atom and calculate the Rydberg constant.
2. To resolve and measure the wavelength separation between the two D-lines of Sodium D_1 and D_2 lines.
3. To compare observed spectral lines (H or He) with Bohr's theoretical predictions.
4. To observe the splitting of spectral lines in the presence of a magnetic field (Zeeman effect).
5. Simulate rate equations for two- and three-level lasers and analyze dynamics.
6. Determine rotational constants from observed microwave absorption spectra of diatomic molecules.
7. Measure spatial coherence and divergence of laser beam.
8. Numerically solve the radial and angular equations and analyze quantum numbers.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VI

COURSE: MAJOR – 13(MJ-13)
PAPER NAME: STATISTICAL MECHANICS

TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

<table>
<tr><th colspan="4">EVALUATION</th></tr>
<tr><th></th><th>External Exam</th><th>Internal Exam</th><th>Practical</th></tr>
<tr><td>Full Marks</td><td>60</td><td>15
(10 Written + 5 Attendance/Overall Class Performance)</td><td>25</td></tr>
<tr><td>Duration of Exam</td><td>3 Hours</td><td>1 Hour</td><td>6 Hours</td></tr>
<tr><td>Pass Marks</td><td colspan="2">30 Marks</td><td>10 marks</td></tr>
</table>

Course Objective:

This course aims to provide students with a thorough understanding of classical and quantum statistics, including the concepts of macrostates and microstate, ensembles, entropy, distribution laws (Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac), and their applications in describing the behavior of particles in various physical systems.

Learning Outcomes:

1. Understand the concepts of microstates, macrostates, ensembles, and entropy in classical statistical mechanics.
2. Apply Maxwell-Boltzmann distribution and partition functions to calculate thermodynamic quantities.
3. Explain blackbody radiation and derive radiation laws using Planck’s quantum theory.
4. Analyze Bose-Einstein statistics, photon gas properties, and Bose-Einstein condensation phenomena.
5. Interpret Fermi-Dirac statistics and apply them to electron behavior in metals, including thermionic and photoelectric emissions.

PART ‘A’

THEORY COURSE CONTENTS:

UNIT-I:

Classical Statistics (15 Lectures): Macrostates & Microstate, Elementary Concept of Ensemble: micro-canonical, canonical, grand canonical, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox & resolution, Sackur-Tetrode equation, Law of Equipartition of Energy (with proof), Applications to Specific Heat and its Limitations.

UNIT-II:

Quantum Theory of Radiation (10 Lectures): Spectral Distribution of Black Body Radiation, Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement Law from Planck's law, Applications.

UNIT-III:

Bose-Einstein and Fermi-Dirac Statistics (20 Lectures): B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas, Bose derivation of Planck's law. Fermi-Dirac Distribution Law, Thermodynamic functions of a strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Thermionic emission, Photoelectric Emission, Richardson equation, Pauli spin paramagnetism.

SUGGESTED READINGS:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill.
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir, 1991, Prentice Hall.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press.
7. An Introduction to Thermal Physics, Daniel V. Schroeder, Addison-Wesley, Reading, Massachusetts, 2000.

8. Statistical Mechanics by Satya Prakash.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Measure specific heats and verify the law of equipartition of energy and explore its limitations.
2. Visualize the distribution of microstates and macrostates using computational methods.
3. Verify the Rayleigh-Jeans approximation in the classical limit.
4. Estimate Fermi energy using thermionic emission experiments.
5. Computationally visualize occupancy of energy states in a Fermi gas at different temperatures.
6. Analyze radiation intensity distribution for different temperatures.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VI

COURSE: MAJOR – 14 (MJ-14) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: DIGITAL ELECTRONICS AND APPLICATIONS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to provide foundational knowledge of number systems, Boolean algebra, and digital logic design. It introduces combinational and sequential circuits, memory devices, and microprocessor architecture. Students will develop the skills to analyze, simplify, and implement digital systems, and gain insight into basic microprocessor operations and components.

Learning Outcomes:

1. Understand number systems, binary arithmetic, and Boolean algebra for digital logic design.
2. Simplify Boolean functions using Karnaugh maps and implement logic circuits using SOP/POS forms.
3. Design and analyze combinational and sequential circuits using basic and universal logic gates.
4. Explain the operation of flip-flops, counters, shift registers, and memory devices.
5. Understand microprocessor architecture and describe the basic components and features of 4-bit to 32-bit systems.

PART ‘A’

THEORY COURSE CONTENTS:

UNIT-I:

Number systems and Boolean algebra (20 Lectures): Positional number system, binary representation, 2’s complement notation, binary addition and subtraction, octal number system, hexadecimal system, binary codes (BCD and ASCII codes), Switching circuits, AND, OR and NOT operations, truth table, Boolean functions, postulates and theorems of Boolean algebra, duality principle, Venn diagram, canonical forms of Boolean functions, simplification of Boolean functions, sum of product (SOP) and product of sum (POS) representations, Karnaugh maps, incompletely specified functions, don't cares.

UNIT-II:

Combinational and sequential circuits (10 Lectures): Logic gates, NAND and NOR as universal gates, realization of logical functions using SOP and POS techniques, XOR gate, decoders, encoders, multiplexers, de- multiplexers, code conversion using logic gates and MSI ICs, half adder, full adder, serial adder, half subtractor, full subtractor, digital comparator, TTL & CMOS.

UNIT-III:

Registers and Memory Devices (15 Lectures): Flip-flops (J-K, S-R, clocked, master-slave, & edge-triggered flip-flops), synchronizer, timer, counter, shift register. Read only memories, shift-register memories, Random-Access Memories. Microprocessor Architecture: Introduction, 4-Bit, 8-Bit, 16-Bit, & 32-Bit systems, components, brief description of 8085/8086 microprocessor.

SUGGESTED READINGS:

1. Digital electronics by G. K. Kharate, Oxford University Press, 2010.
2. Principles of electronics, V. K. Mehta and Rohit Mehta, S. Chand.
3. Electronic Device and Circuit Theory, XIth Edition, Robert L. Boylestad and Louis Nashelsky.
4. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
5. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
6. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7. Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
8. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Construction of half and full adder using XOR and NAND gates and verification of its operation.
2. Verify the truth table of RS, JK, T and D flip-flops using NAND and NOR gates.
3. Encode and decode characters using BCD and ASCII formats.

4. Write a program to convert numbers between binary, octal, decimal, and hexadecimal systems.
5. Design and demonstrate data shifting operations in a shift register.
6. Implement Boolean expressions using logic gates in SOP and POS formats.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VI

COURSE: MAJOR – 15 (MJ-15)
TOTAL CREDITS: THEORY-03, PRACTICAL-01
PAPER NAME: SOLID STATE PHYSICS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to provide students with a comprehensive understanding of the crystal structure of materials, including lattice translation vectors, unit cells, lattice dynamics, magnetic properties, dielectric properties, ferroelectric properties, elementary band theory, and superconductivity, enabling them to analyze the physical properties and behavior of various materials.

Learning Outcomes:

1. Understand crystal structures, lattice vectors, Miller indices, and reciprocal lattices including Brillouin zones and X-ray diffraction principles.
2. Explain lattice vibrations, phonon types, and theories of specific heat in solids like Einstein and Debye models.
3. Describe free electron theory, Fermi energy concepts, band theory, and classify solids based on band structure.
4. Analyze thermal, dielectric, magnetic, and optical properties of solids with relevant physical models.
5. Comprehend fundamentals of superconductivity including Meissner effect, critical parameters, and BCS theory overview.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Crystal Structure and Lattice Dynamics (15 Lectures): Solids: Amorphous and Crystalline Materials, Lattice Translation Vectors, Lattice with a Basis – Central and Non-Central Elements, Unit Cell, Miller Indices, Reciprocal Lattice, Types of Lattices, Brillouin Zones -reciprocal lattice to sc, bcc, &fcc lattices, , Diffraction of X-rays by Crystals, Bragg's Law, Atomic and Geometrical Factor. Lattice Vibrations and Phonons: Linear Mono-atomic and Diatomic Chains, Acoustic and Optical Phonons, Qualitative description of the Phonon Spectrum in Solids, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, T3 law .

UNIT-II:

Energy band (10 Lectures): Free electron theory of metals - thermal & electrical conductivity, Drude-Lorentz theory, Somerfield's theory, Fermi energy, Fermi level, Fermi velocity, density of states, band theory of solids, classification of solids (metals, semiconductor, & insulators) on the basis of band theory, Brillouin zone and origin of band gap, Kronig-Penny model, effective mass of electron, direct & indirect band gap semiconductors.

UNIT-III:

Properties of solids (20 Lectures): Thermal properties- Lattice vibration, vibration of 1-D monoatomic & diatomic lattice, concept of phonon, phonon dispersion relation, specific heat of solids, Dulong-Petit law, Einstein & Debye's theory, density of states. Dielectric properties- Polarization, dielectric constant, polarizability, local electric field, Normal and Anomalous Dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation, Complex Dielectric Constant. Magnetic properties- Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of Diamagnetic and Paramagnetic Domains, Quantum Mechanical Treatment of Paramagnetism, Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains, Discussion of B-H Curve, Hysteresis and Energy Loss. Optical properties- Brief qualitative discussion of optical properties, complex refractive index, extinction coefficient. Superconductivity: Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type I and type II Superconductors, London's Equation and Penetration Depth, Isotope effect, Idea of BCS theory.

SUGGESTED READINGS:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

2. Solid State Physics, S. O. Pillai.

3. Solid State Physics, R. K Puri and V. K Babbar, S. Chand & Company Ltd.

4. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India

5. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning

6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Determine the Hall coefficient of a semiconductor sample.

2. Determine the Coupling Coefficient of a Piezoelectric crystal.

3. Measure the Dielectric Constant of a dielectric Materials with frequency.

4. Measure diffraction angles for a known crystal and verify Bragg's Law.

5. Simulate phonon dispersion relation for monoatomic and diatomic chains.

6. Estimate the band gap energy using thermally activated current in a PN junction diode.

SUGGESTED READINGS:

1. https://phet.colorado.edu/

2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VII

COURSE: MAJOR – 16 (MJ-16)
TOTAL CREDITS: THEORY-03, PRACTICAL-01
PAPER NAME: ELECTRODYNAMICS AND PLASMA PHYSICS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to develop a deep understanding of classical and relativistic electrodynamics and their applications to radiating systems and plasma physics. It also equips students with tools to approach advanced problems in electrodynamics, radiation, and plasma phenomena, with relevance in applied physics contexts.

Learning Outcomes:

1. Analyze electromagnetic fields of moving charges via retarded and Liénard-Wiechert potentials.
2. Understand radiation from accelerated charges, dipoles, and antennas, focusing on energy distribution and angular dependence.
3. Explore relativistic electrodynamics with Lorentz transformations and Maxwell's equations covariance.
4. Learn plasma physics fundamentals: kinetic/fluid models, oscillations, shielding, and wave propagation in magnetized plasmas.
5. Apply concepts to linear antennas, antenna arrays, and plasma confinement devices.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Fields of moving charges and Radiating System (15 Lectures): Retarded Potentials, Lienard-Wiechert potentials, field of a point charge in uniform rectilinear motion, in arbitrary motion, Radiation from an accelerated charged particle at low and high velocity. Radiating System: Oscillating electric dipole, radiation from an oscillating dipole, from a small current element, from a linear antenna, Antenna arrays.

UNIT-II:

Relativistic Electrodynamics (15 Lectures): Transformation equation for current density and charge density, vector potential and scalar potentials, the electromagnetic field tensor, transformation equation for electric and magnetic field, Covariance of Maxwell equation in four tensor form, covariance of Maxwell and transformation law of Lorentz force.

UNIT-III:

Plasma Physics (15 Lectures): Elementary concepts of plasma, derivation of moment equations from Boltzmann equation. Plasma oscillation, Debye shielding, plasma confinement, magneto plasma. Fundamental equations, hydromagnetic waves: magnetosonic waves, Alfven waves, wave propagation parallel and perpendicular to magnetic field.

SUGGESTED READINGS:

1. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
2. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
3. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

PART 'B'

PRACTICAL COURSE CONTENTS:
List of Practical:

1. Analyze the radiation field from a short current-carrying conductor.
2. Simulate and visualize the scalar and vector retarded potentials due to a point charge in uniform motion using computational methods.
3. Simulate the radiation fields of a time-harmonic electric dipole and observe the angular dependence of radiated power.

4. Simulate the force on a charged particle under transformed electric and magnetic fields in different inertial frames.

5. Simulate the oscillation of electrons about equilibrium position in plasma and determine the plasma frequency for various electron densities.

6. Model and analyze how a test charge is shielded in a plasma, and to calculate the Debye length for given plasma parameters.

SUGGESTED READINGS:

1. https://phet.colorado.edu/

2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VII

COURSE: MAJOR – 17 (MJ-17) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: MATHEMATICAL PHYSICS-II **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to equip students with a solid foundation in differential equations, vector calculus, complex analysis, Fourier series, Fourier transforms, and Laplace transforms, providing them with essential mathematical tools for solving problems in various scientific and engineering fields.

Learning Outcomes:

1. Analyze periodic functions and represent them using Fourier series, understanding orthogonality conditions, Dirichlet conditions, and complex representations of Fourier series.
2. Apply Fourier transforms to analyze and represent functions in the frequency domain, understanding properties such as convolution theorem and inverse Fourier transform.
3. Understand Laplace transforms, including their application to elementary functions, properties such as change of scale theorem and shifting theorem, and their use in solving differential equations and convolution problems.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Fourier Series (15 Lectures): 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, Analysis of saw tooth, triangular and square wave form.

UNIT-II:

Integral Transforms (15 Lectures): Fourier transform of trigonometric, Gaussian, finite wave train & other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Laplace Transform (LT) of Elementary functions, Properties of LTs: Change of Scale Theorem, Shifting Theorem, Dirac Delta function, Periodic Functions, Convolution Theorem.LT of derivatives and integral, Inverse LT and applications of LT.

UNIT-III:

Frobenius Method and Special Functions (15 Lectures):: Singular points of second order linear differential equations and their importance, Frobenius method and its applications to differential equations, Legendre, Bessel, Hermite and Laguerre functions, properties and differential equations, generating function, recurrence relation, orthogonality.

SUGGESTED READINGS:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical Physics, H. K. Dass and Rama Verma, S. Chand & Company Pvt. Ltd.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press.
4. Mathematical Methods for Physics & Engineers, K. F. Riley, M. P. Hobson, S. J. Bence, 3rd Ed., 2006, Cambridge University Press.
5. Mathematical physics by B.S. Rajput.

PART ‘B’

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Verify the orthogonality of sine and cosine functions over a given interval.
2. Compute and visualize the Fourier transforms of standard functions like sine, cosine, Gaussian, and finite wave train functions.

3. Demonstrate the representation of the Dirac delta function as the limiting case of a Fourier integral using a numerical approach.
4. Verify the properties of Laplace transforms: linearity, shifting, scaling, and the convolution theorem.
5. Plot Legendre polynomials for various orders.
6. Compute Bessel functions of the first kind and verify recurrence relations and orthogonality.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VII

COURSE: MAJOR – 18 (MJ-18)
PAPER NAME: QUANTUM MECHANICS-II
TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to develop the advanced understanding about mathematical foundation useful to explain the various quantum phenomena such as scattering, perturbation theory and approximation methods.

Learning Outcomes:

1. Understand linear vector spaces, Dirac notation, and operators in quantum mechanics.
2. Analyze angular momentum operators, spin, and related symmetries.
3. Apply quantum scattering theory including partial waves and Born approximation.
4. Utilize time-independent and time-dependent perturbation theories.
5. Interpret physical phenomena such as Stark effect and transition probabilities.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Mathematical Foundation of Quantum Mechanics (15 Lectures): Vectors and Linear vector space, Closure property, Linear independence of vectors, Bases and dimensions. Some examples of linear vector spaces, Dirac's notations, Bra and Ket vectors, Combining bras with kets, Inner product and inner product space, Orthonormality of vectors, Completeness condition, Outer product, Hilbert space and the Coordinate Representation, Operator on a linear vector space, Algebra of linear operators.

UNIT-II:

Angular Momentum (15 Lectures): Commutation relations for angular momentum operators, Eigenvalues and eigenvectors, Pauli spin matrices and spin eigenvectors, Motion in a centrally symmetric field, Clebsch-Gordon Coefficients. Space-time symmetries and conservation Laws for linear momentum, Angular momentum, Energy and Parity. Electron Spin, Exclusion principle, Symmetric and Antisymmetric Wave Functions, Spin-Orbit Coupling, Total Angular Momentum.

UNIT-III:

Perturbation Theory and Scattering(15 Lectures): Time Independent Perturbation Theory (First and Second order), Degenerate and non-degenerate cases, Stark Effect, Time dependent perturbation theory, Transition Probability, Fermi's Golden Rule, Constant and Harmonic perturbation. Differential Scattering Cross Section and Total Scattering Cross Section, Formulation of quantum scattering theory, Scattering amplitude, Scattering of a Wave Packet, Green's function in Scattering theory, Partial wave analysis, Scattering in a Coulomb Field, Optical theorem, Born Approximation, Phase Shifts, Scattering length and effective range for short range potential.

SUGGESTED READINGS:

1. A Text Book of Quantum Mechanics, Mathews, P.M., &Venkatesan, K., TMH.
2. Quantum Mechanics, Merzbacker, E., John Wiley
3. Quantum Mechanics Messiah, A., North-Holland Publishing Co.
4. Quantum Mechanics Schiff, L.I., Tata McGraw-Hill, 3rd Edition 2010
5. Quantum Mechanics Ghatak, A., Narosa Publishing House, New Delhi.
6. Quantum Mechanics, Agarwal, B. K., PHI
7. Modern Quantum Mechanics, J.J. Sakurai
8. Quantum Mechanics, Landau, L.D. &Lifshitz, E.M., Pergman Press
9. Quantum Mechanics Concepts and Applications 2nd Edition NouredineZettili.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Verify the closure property and linear independence of a set of vectors in a finite-dimensional vector space using computational methods.

2. Compute inner products of vectors and verify orthonormality in an inner product space numerically.
3. Compute and visualize the differential and total scattering cross section for given potentials.
4. Simulate the scattering of a Gaussian wave packet from a one-dimensional potential and study reflection/transmission coefficients.
5. Compute and visualize the energy level splitting due to an external electric field (Stark effect) using perturbation theory.
6. Simulate the time evolution of quantum states under a time-dependent potential and compute transition probabilities.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VIII

COURSE: MAJOR – 19 (MJ-19)
TOTAL CREDITS: THEORY-03, PRACTICAL-01
PAPER NAME: NUCLEAR AND PARTICLE PHYSICS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

The course on Nuclear Physics aims to provide students with a comprehensive understanding of nuclear forces, reactions, properties of nuclei, radioactivity decay, accelerators and detectors, as well as an introduction to particle physics. Students will gain knowledge about the fundamental principles governing nuclear interactions and the behavior of subatomic particles.

Learning Outcomes:

1. Understand nuclear forces, scattering processes, nuclear reactions, and their conservation laws.
2. Analyze nuclear properties, radioactivity types, decay mechanisms, and nuclear stability concepts.
3. Explore nuclear models including liquid drop, shell model, and nuclear magic numbers.
4. Examine particle physics fundamentals, quantum numbers, particle classification, and the quark model.
5. Gain insight into nuclear fission, fusion, reactors, and modern particle physics including the Standard Model and beyond.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Nuclear Forces and Reactions (15 Lectures): Ground state of Deuteron, Neutron-Proton Scattering at low energies, Proton-Proton Scattering at low energies, Analysis of n-p and p-p scattering, Interpretation of p-p and n-n scattering. Types of Nuclear Reactions, Conservation Laws, kinematics of reactions, Q-value, Reaction rate, Reaction cross section, Concept of Compound and Direct Reaction, Resonance reaction, Statistical theory of Nuclear reactions, Optical model of nuclear reaction at low energies, Coulomb scattering (Rutherford scattering), Nuclear Fission. Nuclear reactors, Nuclear Fusion, Nuclear Fusion in stars, Fusion reactors.

UNIT-II:

General Properties of Nuclei and Nuclear Models (20 Lectures): Scattering of alpha particles, Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. Nuclear stability and Radioactivity, Activities and half-life, Types of radioactivity- (a) Alpha decay: basics of -decay processes, theory of - emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis, (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **Nuclear Models:** Liquid drop model approach, Semi-empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for Nuclear Shell structure, Nuclear magic numbers, Basic assumption of Shell model, concept of mean field, residual interaction, concept of nuclear force, L-S coupling, j-j coupling, Transformation between L-S and j-j coupling schemes.

UNIT-III:

Particle Physics (10 Lectures): Four fundamental interactions. Quantum numbers -- spin, isospin, strangeness, parity, hypercharge, Conservation laws, Particle classification -- hadron and lepton, Quark model of hadron -- baryon and meson, Gell-Mann plot, Elementary discussion of key experiments that led to the current understanding of unified electro-weak interaction and strong interaction, Standard Model, Elementary exposition of diagrammatic techniques (without actual calculation) used to evaluate cross-sections of production processes and decay rates, Introduction to physics beyond the Standard Model.

SUGGESTED READINGS:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Nuclear Physics by D. C. Tayal, Himalaya Publishing House.
3. Nuclear Physics by S. N. Ghoshal, S. Chand & Company.
4. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
5. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.

6. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).

7. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. To determine the half-life of a radioactive isotope (using virtual lab or by simulation).
2. To verify that the intensity of gamma radiation decreases with square of the distance (use virtual lab or by simulation).
3. Study of attenuation of beta or gamma radiation in lead/aluminum and find absorption coefficient (use virtual lab or by simulation).
4. Compute the binding energy, magnetic moment, and estimate the size of the deuteron using simple potential models.
5. Simulate Coulomb (Rutherford) scattering and plot the differential cross-section as a function of angle.
6. Determine nuclear radius from alpha particle scattering data and plot nuclear radius as a function of mass number (A).
7. Plot binding energy per nucleon versus mass number using empirical data and interpret stability features.
8. Verify exponential decay law using simulated data for alpha, beta, and gamma decay and extract half-lives.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VIII

COURSE: MAJOR – 20(MJ-20)
PAPER NAME: DISSERTATION

TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objectives:

Enhance students' communication skills through active participation in seminars and group discussions. Prepare them for academic and professional environments where effective communication and teamwork are vital for success. Foster confidence, clarity, and coherence in expressing ideas, enabling students to engage meaningfully in collaborative and interdisciplinary settings.

Course Outcomes:

1. Develop effective verbal and non-verbal communication skills through seminars and group discussions.
2. Demonstrate confidence, clarity, and coherence in presenting and articulating ideas.
3. Collaborate successfully in academic and professional settings, applying interpersonal skills and teamwork strategies in diverse and interdisciplinary environments.

PART 'A'

Course Contents:

The Head of the Department and faculty members will assign topic to the students from the course content of semester VII and VIII. Students will have to work under the supervision of a teacher of the department. Each and every student has to submit electronically typed hardbound dissertation along with the raw data on a week before the examination.

Evaluation Process: Presentation and the report submitted by the students will be evaluated by one external member and one internal member. The External Member may be a Permanent faculty members working in the postgraduate department of the university or other colleges or Retired Professor/Associate Professor/Assistant Professor of the university.

Distribution of marks:

Dissertation Report	25 marks
Presentation	50 marks
Subject Knowledge	25 marks

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SEMESTER - VII

COURSE: ADVANCE MAJOR – 1(AMJ-1) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ADVANCED QUANTUM MECHANICS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to introduce approximation methods, relativistic wave equations, identical particles, and quantum entanglement. It also aims to develop the concepts in quantum field theory, including field quantization and gauge invariance, preparing students for research in modern theoretical physics and applications in atomic, particle, and quantum information science.

Learning Outcomes:

1. Apply approximation methods like variation principle and WKB to analyze non-exactly solvable quantum systems.
2. Understand and solve relativistic quantum equations such as the Klein-Gordon and Dirac equations, and interpret their physical implications.
3. Distinguish between bosons and fermions using exchange symmetry, and utilize second quantization and Fock space formalism.
4. Analyze quantum entanglement using reduced density matrices, entanglement entropy, and Bell's inequalities.
5. Comprehend basic principles of quantum field theory, including field quantization, propagators, Feynman diagrams, and gauge invariance.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Approximation methods (10 Lectures): Variation methods and its application to Ground State of Hydrogen Atom and First excited state of Harmonic oscillator, WKB approximation, Interaction with classical electromagnetic fields,

UNIT-II:

Relativistic Quantum Mechanics (15 Lectures): Klein-Gordon (K-G) equation, Limitations of K-G equations, Dirac equation and matrices, Plain wave solution of Dirac equation, Probability density and current density, Concept of negative energy state of electron. Central field problem: exact solution, Hydrogen atom and hyperfine structure, Discrete symmetries: parity, charge reversal, time reversal.

UNIT-III:

Identical Particles and Quantum Field Theory (20 Lectures): Exchange symmetry: Bosons and Fermions, Second quantization formalism, Fock space and creation/annihilation operators, Entanglement and Bell's inequalities, Reduced density matrices and quantum entropy, Entanglement entropy. Quantization of scalar and spinor fields, Canonical quantization and path integral quantization, Normal ordering and vacuum energy, Propagators and Feynman diagrams, Gauge invariance.

SUGGESTED READINGS:

1. A Text Book of Quantum Mechanics, Mathews, P.M., &Venkatesan, K., TMH.
2. Quantum Mechanics, Merzbacker, E., John Wiley
3. Quantum Mechanics Messiah, A., North-Holland Publishing Co.
4. Quantum Mechanics Schiff, L.I., Tata McGraw-Hill, 3rd Edition 2010
5. Quantum Mechanics Ghatak, A., Narosa Publishing House, New Delhi.
6. Quantum Mechanics, Agarwal, B. K., PHI
7. Modern Quantum Mechanics, J.J. Sakurai
8. Quantum Mechanics, Landau, L.D. &Lifshitz, E.M., Pergman Press

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Compute the energy of the first excited state of a one-dimensional quantum harmonic oscillator and compare it with the exact solution.
2. Numerically solve the Klein-Gordon equation for a free particle and study the behavior of its solutions.
3. Simulate the behavior of two identical particles (bosons and fermions) and verify the exchange symmetry of their wavefunctions.
4. Compute the positive and negative energy solutions of the Dirac equation and visualize their spinor components.
5. Numerically evaluate the path integral for a free particle and a harmonic oscillator.
6. Simulate entangled states and verify the violation of Bell's inequality.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VIII

COURSE: ADVANCE MAJOR – 2 (AMJ-2) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: CLASSICAL DYNAMICS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to develop a foundational understanding of small amplitude oscillations, fluid dynamics, and special relativity. Students will explore normal modes, fluid flow principles, and relativistic concepts including Lorentz transformations and four-vectors, enabling them to analyze classical and relativistic physical systems using mathematical and conceptual tools.

Learning Outcomes:

1. Understand stable equilibrium and analyze small amplitude oscillations using normal modes.
2. Apply matrix methods to determine eigen-frequencies and eigen-vectors in coupled oscillatory systems.
3. Explain fluid properties, continuity equation, Poiseuille's law, and fluid-electric current analogies.
4. Solve problems involving Navier-Stokes equation and interpret flow types using Reynolds number.
5. Comprehend special relativity concepts, Lorentz transformations, four-vectors, and their physical significance.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Small Amplitude Oscillations (15 Lectures): Minima of potential energy and points of stable equilibrium, small amplitude oscillations about the minimum, normal modes of longitudinal simple harmonic oscillations (maximum 3 masses connected by 4 springs). Kinetic energy (T) and potential energy (V) in terms of normal co-ordinates. T and V matrices: finding eigen-frequencies and eigen-vectors using these matrices.

UNIT-II:

Fluid Dynamics (10 Lectures): Density ρ and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe. Analogy between liquid flow and current flow, rate of liquid flow through capillaries in series and in parallel combination. Navier Stokes equation, Reynolds number.

UNIT-III:

Special Theory of Relativity (20 Lectures): Postulates of Special Theory of Relativity, Lorentz Transformations, Consequences of Lorentz Transformations: length contraction, Simultaneity, Time dilation, Addition of velocities, Minkowski space, The invariant interval, light cone and world lines, Space- time diagrams. **Four-vectors**: space-like, time-like and light-like, Examples of Four-vectors: Position Four-vectors, Velocity Four-vectors, Momentum Four-vectors, Acceleration Four-vectors, and Four-force Minkowski force, Doppler Effect from a four-vector perspective, Conservation of Four-momentum, Geometrical Interpretation of Lorentz Transformations, Simultaneity, Length Contraction and Time Dilation.

SUGGESTED READINGS:

1. Boylestad R. L. and Nashelsky L., Electronic Devices and Circuit Theory, Pearson.
2. RaychaudhuriBarun, Electronics: Analog and Digital, Cambridge University Press.
3. Cathey J. J., Schaum's Outline of Theory and Problems of Electronic Devices and Circuits, McGraw-Hill.
4. Helfrick A. D. and Cooper W. D., Modern Electronic Instrumentation and Measurement Techniques, PHI.
5. Malvino A. P. and Bates D. J., Electronic Principles, McGraw-Hill Education.
6. Millman J. and Halkias C. C., Integrated Electronics: Analog and Digital Circuits and Systems, McGraw-Hill, Inc.
7. Streetman B. G. and Banerjee S.K., Solid State Electronic Devices, PHI.
8. Gayakwad R. A., Op-Amps and Linear Integrated Circuits, Pearson.

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Compute and visualize time-like, space-like, and light-like intervals and vector magnitudes in spacetime.
2. Compute the frequency of small oscillations about a stable minimum of a given potential (e.g., quadratic, anharmonic).
3. Simulate the normal modes and frequencies of longitudinal oscillations of a system of 2 masses and 3 springs.
4. Demonstrate conservation of mass in fluid flow using simulated fluid streamlines.
5. Compute time and position transformations between two inertial frames using Lorentz transformation equations.
6. Simulate the four-velocity and four-acceleration for uniformly moving and accelerating particles.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VIII

COURSE: ADVANCE MAJOR – 3(AMJ-3) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ADVANCED STATISTICAL MECHANICS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objective:

This course aims to develop a comprehensive understanding of the principles and mathematical foundations of thermodynamics, statistical mechanics, and critical phenomena. It introduces students to classical and modern approaches for analyzing many-body systems, including interactions, fluctuations, phase transitions, and time-dependent processes.

Learning Outcomes:

1. Apply thermodynamic principles and Maxwell relations to physical systems like ideal gases, magnetic, and dielectric materials.
2. Analyze interacting many-body systems using cluster expansion, correlation functions, and derive equations of state.
3. Explain the theory of phase transitions and critical phenomena using models like the Ising model, Landau theory, and mean-field approximations.
4. Use renormalization group methods to understand scaling, universality, and critical exponents in low-dimensional systems.
5. Describe time-dependent phenomena such as Brownian motion, linear response, and fluctuation-dissipation relations using Langevin and Kubo formalisms.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I:

Review of Thermodynamics (15 Lectures): Extensive and intensive variables, Laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, Applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material, Binomial, Poisson and Gaussian distributions, Central limit theorem, Cluster expansions, Equation of State, Virial coefficients, Pair correlation function and thermodynamic properties, Structure factor, Ornstein-Zernike equation, Debye-Hueckel theory.

UNIT-II:

Phase transitions and critical phenomena (15 Lectures): Gas-liquid and paramagnetic-ferromagnetic transitions, Ising model, Equivalence with other models, Spin-spin correlation function, Mean-field theory, Landau theory. Phase transitions and thermodynamic functions, Second-order transition and critical exponents, Mean field theories, Fluctuations, Upper and lower critical dimensions, Scaling and universality, Renormalization group formulation, Flows, Fixed points, Examples of 1D and 2D Ising systems, Migdal-Kadanoff procedure, Momentum shell renormalization group, The Gaussian model.

UNIT-III:

Time dependent phenomena(15 Lectures): Dynamic correlation and response functions, Symmetry and dispersion relations, Brownian motion and Langevin equations, Velocity auto-correlation and self-diffusion, Linear response theory, Dissipation, The fluctuation-dissipation theorem, The Kubo formula, Onsager's postulate.

SUGGESTED READINGS:

1. Statistical Mechanics: R. K. Pathria (Elsevier).
2. Statistical Mechanics: L. D. Landau and E. M. Lifshitz (Pergamon).
3. Equilibrium Statistical Physics: M. Plischke and B. Bergerson (World Scientific).
4. Principles of Condensed Matter Physics: P. M. Chikin and T. C. Lubensky (Cambridge University Press).
5. Statistical Physics of Fields: M. Kardar (Cambridge University Press).
6. Statistical Physics-I and -II: Kubo, Toda and Ashitsume (Springer).

PART 'B'

PRACTICAL COURSE CONTENTS:

List of Practical:

1. Simulate P-V-T behavior of an ideal gas and validate the ideal gas law across different thermodynamic paths.
2. Compute virial coefficients from model interaction potentials using low-order cluster expansions.
3. Simulate the random walk of a Brownian particle and compute mean square displacement over time.
4. Simulate the Ising model and observe the phase transition and magnetization curves.
5. Compute and plot the spin-spin correlation function as a function of distance and temperature in the Ising model.
6. Apply the Kubo formula to compute conductivity or susceptibility from correlation functions.

SUGGESTED READINGS:

1. https://phet.colorado.edu/
2. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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SEMESTER - VII

COURSE: RESEARCH METHODOLOGY – 1(RM-1) **TOTAL CREDITS:** THEORY-04
PAPER NAME: RESEARCH METHODOLOGY **TEACHING HOURS:** THEORY-60

EVALUATION		
	External Exam	**Internal Exam**
Full Marks	**75**	25 (20 Written + 5 Attendance/Overall Class Performance)
Duration of Exam	3 Hours	1 Hour
Pass Marks	40 Marks	

Course Objective:

This course aims to inculcate research aptitude among the learners and equip them with knowledge and skills required to successfully undertake various steps in the research process.

Learning Outcomes:

1. Able to analyze research concepts, its types and steps in the research process.
2. Identify the appropriate research problems and approach to solve them.
3. Recognize various techniques of data analysis and interpretation, and learn different mathematical modeling.
4. Develop the sense of ethics in research process.
5. Able to prepare a complete research report in appropriate format and searching of reputed journals for publishing their articles/reports.

Course Content:

Introduction to Science and Scientific Thinking (Lectures: 10): What is science? Characteristics of scientific knowledge, Objectivity vs subjectivity, scientific reasoning: Inductive and deductive logic, Examples of scientific discoveries and logical inference.

Scientific Method, Hypothesis and scientific communication (Lectures: 15): How scientists ask questions, Hypotheses: definition, examples, testability, Simple data collection and experimental ideas, Understanding variables, observations, and inference**.** Basics of Scientific Communication: Writing lab reports and project summaries, Abstract, introduction, and conclusion, Preparing posters and visual aids, Basics of citation and plagiarism.

Research Ethics, Scientific Attitude, Scientific Database and Publications (Lectures: 25): Scientific honesty and integrity, what is plagiarism? How to avoid it? Importance of accurate data recording and openness in research, Role of collaboration and communication in research. **Scientific Database and Publications:** UGC Care, Scopus, Google Scholar, Web of Science, Science Citation Index (SCI), Orchid, Archives. Types of Publications: Articles, Books, Journals, Archives, Conference Papers, Theses, Patents, Journal Impact: Journal citation reports, SCImago Journal Rank (SJR), Cite score, Source Normalized Impact per Paper (SNIP), h-index.

Note: Internal assessment will include assignments, short project reports, and classroom participation.

SUGGESTED READINGS:

1. Soumitro Banerjee, Research Methodology for Natural Sciences, IISc Press, 2022.
2. Research Methodology- C. R. Kothari

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SEMESTER - VIII

COURSE: RESEARCH PROJECT/DISSERTATION – 1(RP/D-1) **TOTAL CREDITS:** 08
PAPER NAME: RESEARCH PROJECT OR DISSERTATION

Note: Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year.

Course Objectives:

The objectives of the course is to facilitate students to carry out extensive research and develop as self-guided learning and analytical skills through problem and gap identification, development of research methodology, interpretation of findings and presentation of results.

Learning Outcomes: After completion of the course, the learners will be able to:

1. Gain in-depth knowledge in the major field of study.
2. Design and justify research methodology.
3. Utilize appropriate research methodology for data collection
4. Analyze the collected data and draws conclusions accordingly.

Course Contents:

The HOD of the department has to allot supervisor to the students from among the faculty members who have PhD degree. After that the students have to select a research problem with the help of the supervisor and they have to submit a summary or research proposal to the department. Thereafter, the HOD of the department will organize a meeting of the Departmental Committee and after the presentation of the student the committee will approve or reject his/her synopsis/research proposal. Students will start their research work after getting approval from the departmental committee.

At the end of the semester the student has to submit the project dissertation to the department and that will be evaluated by the following members:

(i) HOD of the Department–Chairmen

(ii) HOD, University Department/ Nominated Faculty - External member

(ii) Faculty members of the department – Internal member

External members may be any of the following:

1. Permanent professors working in the postgraduate department of the university or other colleges who have the qualification to become PhD supervisors.

OR

2. Retired Professor/Associate Professor/Assistant Professor of the university who has been supervising PhD scholar.

OR

3. Professor/Associate Professor/Assistant Professor of the outside university who has been supervise PhD scholar.

Note- The project dissertation will be evaluated under the following heads:

1. Motivation for the choice of topic
2. Project dissertation design
3. Methodology and Content depth
4. Results and Discussion
5. Future Scope & References
6. Participation in Internship programme with reputed organization
7. Application of Research technique in Data collection
8. Report Presentation
9. Presentation style Broad

Guidelines for distribution of marks may be as follows or as appropriate:

Assessment of project synopsis	75 marks
Assessment of project Thesis	100 marks
Viva-voce	25 marks

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