National Curriculum and Credit Framework (NCCF)

Syllabus

For

B. Sc (Honours) in Physics

w.e.f. Academic Session 2023-24

Kazi Nazrul University

Asansol, Paschim Bardhaman

West Bengal 713340

SEMESTER -I

MAJOR COURSE

Course Name: Mechanics and General properties of Matter

Course Code: BSCPHSMJ101

Course Type: Major **(Theory and Practical)**	Course Details: MJC -1			L-T-P: 3-0-4	
Credit: 5	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	20	**35**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1.Understand vector calculus, classical mechanics of single as well as system of particles within the scope the Newtonian formulation.
2. Understand the dynamics of rigid body and concept of moment of inertia. Study of moment of inertia of different bodies and its applications.
3. Examine phenomena of simple harmonic motion and the distinction between undamped, damped and forced oscillations and the concepts of resonance and quality factor in a driven system.
4. Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
5. Study the properties of matter, response of the classical systems to external forces and their elastic deformation and its applications and comprehend the dynamics of Fluid and concept of viscosity and surface tension along with its applications.

Course Content

MJC-1: Mechanics & General Properties of Matter

45 Hrs

Vector Calculus : Vector triple product(review); Derivatives of vectors; Gradient, Divergence, Curl of a vector field; Vector integrations-line, surface and volume integration; Gauss' divergence theorem, Stoke's theorem, Green's theorem (statement only with simple applications); Introduction to Orthogonal curvilinear Co-ordinate systems, unit vectors, Jacobian; Special cases: plane, spherical and

cylindrical co-ordinate systems; Infinitesimal line segment, area and volume elements in them.

10L

Mechanics of Single Particle: Introduction to Inertial & Non-inertial reference frames; Velocity and Acceleration - tangential and normal components, Radial and Cross-radial components; Newton's laws, Inertial frame, Work, Energy, Impulse of a force, Freely falling bodies, Motion in a resistive medium. Projectile motion. Conservative force and concept of potential; Conservation of energy; Dissipative forces; Translation invariance and conservation of linear momentum; Central force (preliminary idea) & Conservation of angular momentum; Torque; Brief reference to fundamental forces in nature.

6L

Oscillations: Oscillations: Simple Harmonic Motion and its properties, energy of a simple harmonic oscillator, Damped oscillations: under damped, over-damped, and critically damped motion, Forced Oscillations and Resonance, Q factor and Sharpness; Examples of Oscillators from various branches of physics.

8L

Gravitation: Kepler's laws, Newton's law of gravitation, Motion of satellites in circular orbit. Geosynchronous orbits.

2L

Systems of particles: Degrees of freedom, Centre of mass and Centre of gravity, Momentum, Angular momentum, Torque, Kinetic energy of a system of particles; Conservation of linear momentum, angular momentum, and Energy for a system of particles; Centre of mass motion and Centre of mass coordinate; Examples: two coupled harmonic oscillators, two-body systems with (i) gravitaional, (ii) Coulomb interaction etc.

5L

Rigid body Dynamics : Concept of rigid body, Euler's theorem, General motion of rigid bodies: Chasle's theorem, Rotational motion about an axis, Moment of inertia, Radius of gyration, Perpendicular and Parallel Axis Theorems; Moment of inertia of a uniform body-Solid and hollow cylinders, Solid and hollow spheres, Rectangular plane, thin rod; Rotational energy, Conservation of energy, Work and Power, Motion of a flywheel, Theory of compound pendulum- Bar and Kater's pendulum, Foucault Pendulum; determination of "g"; Principal axis and Product of Inertia; Rotating Cordinate & Coriolis force.

7L

General properties of matter: Elasticity: Relation between different elastic moduli and Poisson's ratio, Torsional pendulum, Bending of beam;

Surface Tension: Angle of contact, surface tension and surface energy, pressure difference across curved surface example, excess pressure inside spherical liquid drop;

Viscocity: Streamline flow, turbulent flow, equation of continuity, determination of coefficient of viscosity by Poiseulle's method, Stoke's method. Bernoulli's theorem and its applications.

7L

References/ Suggested Readings

1. *Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill)*
2. *Classical Mechanics – J. C. Upadhyay, (Himalaya Publ.).*
3. *Introduction to Classical Mechanics - R. G. Takwale and P. S. Puranik (Tata McGraw-Hill).*
4. Theoretical Mechanics - M. R. Spiegel, (Schaum's Outline Series) (McGraw-Hill).
5. Berkeley Physics Course, Vol – I (Mechanics) (Mc Graw Hill).
6. Advanced Accoustics- D. P. Raychaudhury.
7. Waves and Oscillations by N K Bajaj
8. Waves and Oscillations by R. N. Chowdhury
9. An Introduction to Mechanics by Kleppner and Kolenkow
10. Classical Mechanics by Rana Joag
11. Introduction to classical Mechanics with problems and solutions by Davis Morin, Cambridge University Press
12. Feynman Lectures Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
13. Elements of properties of matter by D.S. Mathur
14. A Treatise on general properties of matter by Sengupta and Chatterjee

Students can also explore these sites for additional reading -
https://nptel.ac.in/courseshttps://ocw.mit.edu/search/?q=courses

Experiments to be performed in the first semester (At least 5 experiments have to be performed):

1. To study the Motion of Spring and calculate (a) Spring constant, (b) Acceleration due to gravity.

2. To determine the Moment of Inertia of a Flywheel / regular-shaped body.

3. To determine Coefficient of Viscosity of water by Capillary Flow (Poiseuille‟s) Method.

4. Determination of Young‟s modulus by method of flexure.

5. To determine the Young's Modulus of a Wire by Optical Lever Method.

6. To determine the elastic Constants of a wire by Searle‟s method.

7. To determine the value of acceleration due to gravity using Bar Pendulum.

8. 7. To determine the value of acceleration due to gravity using Kater’s Pendulum.

9. Determination of surface tension of a liquid by Jaeger‟s method.

10. Determination of surface tension of a liquid by capillary-rise method.

11. Determination of the rigidity modulus of a wire by statical /dynamical method

Reference Books for Laboratory Experiments:

1. Physics through experiments	B. Saraf	Vikas Publications
2. A laboratory manual of Physics for undergraduate classes, 1st Edition,	D P Khandelwal	Vikas Publications.
3. B.Sc. Practical Physics (Revised Edition)	C. L Arora	S.Chand& Co.
4. An advanced course in practical physics.	D. Chatopadhyay, PC Rakshit, B. Saha	New Central Book Agency Pvt Ltd.

MINOR COURSE

Course Name: Mechanics and General properties of Matter

Course Code: BSCPHSMN101

Course Type: Minor **(Theory and Practical)**	Course Details: MNC-1			L-T-P: 3-0-4	
Credit: 5	Full Marks: **100**	CA Marks		ESE Marks	
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Oscillations: Oscillations: Simple Harmonic Motion and its properties, energy of a simple harmonic oscillator, Damped oscillations: under damped, over-damped, and critically damped motion, Forced Oscillations and Resonance, Q factor and Sharpness; Examples of Oscillators from various branches of physics.

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10. Classical Mechanics by Rana Joag
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4. An advanced course in practical physics.	D. Chatopadhyay, PC Rakshit, B. Saha	New Central Book Agency Pvt Ltd.

MD COURSE

COURSE NAME: PHYSICAL SCIENCE

COURSE CODE: MDC101

Course Type: MD (Theory)	Course Details: **MDC-1**			L-T-P: **3-0-0**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
			15		**35**

Learning objectives:

1) *On completion of this course students should be able to demonstrate a comprehensive understanding of the fundamental concepts of matter, energy, gravity, and space, as well as their applications in various fields including medicine, communication, and modern storage technology.*

2) Students will also be able to critically analyze the universe's structure and evolution based on the Big Bang theory.

3) Additionally, they should have an awareness of the role of physics in everyday life and technological advancements.

Course Content
MDC-1: Physical Science

Matter and Energy

What is matter? Constituents of matter (upto elementary particles), States of Matter, Fundamental forces in Nature

What is energy?, Types of energy, Conservation of energy dissipation of energy, Conversion of one form of energy to another, Equivalence of matter and energy, energy generation and distribution in our daily life (Nuclear reactors, electrical energy), Renewable and Non-renewable sources of energy; Solar energy, tidal energy, hydro energy

Gravity, Force and Space:

The force of Gravity; Planetary motion, Newton's third law; Weightlessness; Low earth orbit; Geosynchronous satellites; Spy satellites; Medium Earth Orbit satellite; Circular Acceleration; momentum; Rockets; Airplanes, helicopters and fans; Hot air and helium balloons;

Structure of the Universe (Milkyway, solar system, planets, comets), Evolution of the Universe (Big Bang theory)

Applications of Physics

Medical Physics: stethoscope, x-ray, Ultrasound, Laser, Endoscopy, Colonoscopy, NMR, Pet-scan, Radiation- radiation hazards and safety

Communication: optical communication, radars, broad-band, mobile communication

Modern storage system: magnetic storage, solid state devices, holography

Skill Enhancement Course

COURSE NAME: COMPUTER PROGRAMMING

Course Code: BSCPHSSE101

Course Type: SEC-1 (Practical)	Course Details: **SEC-1**			L-T-P: 0-0-6	
Credit: 3	Full Marks: 5**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		20	

Course Content

SEC-1: Computer Programming

1. **Introduction and Overview**: Computer architecture and organization, memory and Input/output devices.

2. **Basics of scientific computing:** Decimal, Binary, octal and hexadecimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

3. **Errors and error Analysis**: Truncation and round off errors, Absolute and relative errors, Floating point computations.

4. **Programming fundamentals:** Introduction to Programming, constants, variables and data types, simple and logical operators and Expressions, I/O statements, Input and output statements. Reading Input and sending output from/to files., Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings. user defined functions, Pointers, Structures and Unions, Idea of classes and objects (for C/C++).

Sample Programming (suggested at least eight):

1. (a) Conversion of components of a vector among cartesian, polar and cylindrical coordinate systems. (b) Conversion of list of temperatures from celsius to fahrenheit scale. (c) Calculating the positions,

velocities of a particle from given mass, acceleration. (d) Finding the real / complex roots of a quadratic equation using Sridharacharya method.
2. To check the divisibility of an integer and find a set of prime numbers.
3. Conversion of a number between decimal, binary, octal, hexadecimal number systems.
4. Find the area / perimeter of circle / square /ellipse, volume of sphere / cube etc. using user defined functions.
5. Generation of terms, sum, ratios for arithmetic, geometric and Fibonacci / series.
6. To evaluate an infinite series with pre-assigned accuracy.
7. To find the largest/second largest/smallest of a given list of numbers. Find their locations in a sequence.
8. Sorting of numbers in ascending / descending order.
9. To generate a frequency distribution, mean, mode, median (from formula), standard deviation , correlation functions etc from a given data.
10. Fitting an experimental data with linear least-square method.
11. To find the trace of a square matrix. Find the sum, difference and product of two square matrices.
12. Generation of pseudo-random numbers and test their auto-correlations.
13. To write in and read from an external file in a program.

References/ Suggested Readings:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Schaum"s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn. , 2007, Wiley India.

Semester-II:

MAJOR COURSE

Course Name: Electricity and Magnetism

Course Code: BSCPHSMJ201

Course Type: MJC -2 **(Theory and Practical)**	Course Details: MJC -2			L-T-P: 3-0-4	
Credit: 5	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	20	**35**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. *Explain the properties of (i) the electric field produced due to charges at rest; (ii) the magnetic field produced due to steady current, both in free-space and inside matter.*
2. *Develop an understanding on the unification of electric and magnetic fields and Maxwell's eqution governing electromagnetic waves.*
3. *Understand the phenomenon of resonance in LCR AC-circuits, sharpness of resonance, Q- factor, Power factor and the comparative study of series and parallel resonant circuits.*

Course Content

MJC-2: Electricity and Magnetism

45 Hours

Electric Field for a point charge : Concept of charge, Conservation and quantization of charge, Coulomb's law, Electric field strength, electric field lines, point charge in an electric field; Electric dipole. work done by a charge (derivation of the expression for potential energy).

2L

Electrostatic potential for a point charge : Electric potential, line integral, gradient of a scalar function, relation between field and potential. Potential due to point charge and Constant potential surfaces. Poisson's and Laplace's equations. Uniqueness Theorem.

3L

Multipole expansion of potential : Potential and electric field due to a dipole. Multipole expansion – monopole, dipole, quadrupole.

2L

Gauss law in Electrostatics : Electric Flux, Gauss's law, Continuous Charge distribution, Calculation of Electric fields of a (i) spherical charge distribution, (ii) line charge and (iii) an infinite flat sheet of charge. Calculation of Potential.

3L

Concept of Voltage and current Sources : Concept of Voltage and Current Sources, Kirchhoff's Laws, Network Theorems- Thevenin's, Norton's, Maximum Power Transfer Theorem, Reciprocity Theorem.

4L

Electrostatics in Conductors and Dielectrics : Electric field and surface charge density for conductors, Electric Polarisation (atomic view) and bound charge densities for Dielectric materials, Displacement Vector and Gauss's law in dielectrics. Capacitors-parallel plate capacitor with dielectric inside, Electrostatic Energy stored in a capacitor.

5L

DC steady currents : Electric currents and current density. Lorentz Force on a moving charge. Electrical conductivity and Ohm's law. Physics of electrical conduction, conduction in metals and semiconductors, circuit elements and circuits: Transient currents in RC, LR and LCR circuits.

4L

Magnetostatics : Definition of magnetic field, Ampere's law and Biot-Savart law (magnetic force and magnetic flux), Magnetic force on a current carrying conductor. Magnetic moment of a current-carrying circular loop, electric current in atoms, electron spin and magnetic moment, Hall effect in a conductor.

5L

Magnetic materials : Magnetic intensity and magnetic induction, Intensity of magnetization, Susceptibility, Permeability, Types of magnetic materials: diamagnetic, paramagnetic and ferromagnetic materials. Magnetization and magnetic susceptibility.

3L

Electromagnetic Induction : Electromagnetic induction, conducting rod moving in a magnetic field, Faraday's laws of induction, Lenz's Law, expression for self-inductance and energy stored in a magnetic field. Mutual inductance**.**

4L

AC circuits : RMS and average value of AC, Response of RL, RC, LC, LCR circuits using j-operator method, quality factor, admittance and impedance, power and energy in series and parallel resonance AC circuits. AC bridges- Anderson bridge, Wien bridge, De'Sauty's bridge.

5L

Electromagnetic waves : Equation of continuity, Maxwell's equations, Brief reference to Magnetic Monopole; Introduction to Gauges; displacement current, equation for propagation of electromagnetic wave, transverse nature of electromagnetic wave, energy transported by electromagnetic waves. Poynting vector.

5L

References/ Suggested Readings

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

2. Electricity and Magnetism, By Rakshit and Chatterjee

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

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

5. Feynman Lectures Vol.2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education

6. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw-Hill Education

Experiments to be performed in the Second semester (At least 6 experiments has to be performed):

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. Measurement of magnetic field strength B and its variation in a solenoid (determinination of dB/dx).

7. To verify the Thevenin and Norton theorems in a wheatstone bridge.

8. To verify the superposition, and maximum power transfer theorems in a wheatstone bridge.

9. 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.

10. To study the response curve of a parallel LCR circuit and determine its (a) anti-resonant frequency and (b) Quality factor Q.

11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer

12. Determine a high resistance by leakage method using Ballistic Galvanometer.

13. To determine self-inductance of a coil by Rayleigh's method.

14. To determine temperature co-efficient of resistance of a metal / semiconductor by a meter-bridge.

MINOR COURSE

Course Name: Electricity and Magnetism

Course Code: BSCPHSMN201

Course Type: Minor **(Theory and Practical)**	Course Details: MNC-2			L-T-P: 3-0-4	
Credit: 5	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
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3. *Understand the phenomenon of resonance in LCR AC-circuits, sharpness of resonance, Q- factor, Power factor and the comparative study of series and parallel resonant circuits.*

Course Content

MNC-2: Electricity and Magnetism

45 Hours

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Electrostatic potential for a point charge : Electric potential, line integral, gradient of a scalar function, relation between field and potential. Potential due to point charge and Constant potential surfaces.

Poisson's and Laplace's equations. Uniqueness Theorem.

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Multipole expansion of potential : Potential and electric field due to a dipole. Multipole expansion – monopole, dipole, quadrupole.

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12. Determine a high resistance by leakage method using Ballistic Galvanometer.

13. To determine self-inductance of a coil by Rayleigh's method.

14. To determine temperature co-efficient of resistance of a metal / semiconductor by a meter-bridge.

Skill Enhancement Course

(Any one from the two listed below will be provided)

Course name: Electrical Circuits and Network Skill

Course Code: BSCPHSSE201

Course Type: SEC (Practical)	Course Details: SEC-2			L-T-P: 0-0-6	
Credit: 3	Full Marks: 50	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		20	

Course Content

SEC-2: Electrical Circuits and Network Skill

1. Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law, Series, parallel, and series-parallel combinations of resistances, capacitor and inductor. ACElectricity and DC Electricity. Response of resistor, inductors and capacitors in DC or AC circuits., Familiarization with voltmeter, ammeter and multimeter.

2. Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

3. Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

4. Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Basic operation of transformers.

5. Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

6. Solid-State Devices: Identification of resistors, inductors, capacitors, diode, transistor and ICs. Colour code reading and value determination of carbon resistances.

7. Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device).

8. Electrical Wiring: Different types of conductors and cables. Voltage drop and losses across cables and conductors. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Joining cables, Basics of House wiring, preparation of extension board.

Suggested Experiments (at least five):

1. Determine the values of resistors from their colour code and their effect on series and parallel connection.
2. Designing equivalent star and delta network.
3. Preparation of extension board for use in house wiring (220 V AC).
4. Two-way Switch connections.
5. Drawing of lay out for a prototype connections in domestic purposes.
6. Pin identification of a 741 IC and design an inverting amplifier.
7. Using multimeter determine the values of resistance, capacitor, inductor and construct a series LCR circuit with a known frequency ac voltage source. Draw the phrasor diagram by determining the voltages across each components.
8. Using multimeter determine the values of resistance, capacitor, inductor and construct a parallel LCR circuit with a known frequency ac voltage source. Draw the phrasor diagram by determining the voltages across each components.
1. Fabrication of tank circuit and study of signal generation of particular frequency.

References/ Suggested Readings:

1. A text book in Electrical Technology - B L Theraja - S Chand & Co.
2. A text book of Electrical Technology - A K Theraja
3. Performance and design of AC machines - M G Say ELBS Edn.

Skill Enhancement Course

Course Name: Basic Instrumentation Skills

Course Code: BSCPHSSE202

Course Type: SEC (Practical)	Course Details: **SEC-2**			L-T-P: 0-0-6	
Credit: 3	Full Marks: 50	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		20	

Course Content

SEC-2: Basic Instrumentation Skills

1. Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects.

2. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. specifications of a multimeter and their significance.

3. Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specification of an electronic Voltmeter/Multimeter and their significance.

4. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifieramplifier. Block diagram ac millivoltmeter, specifications and their significance.

5. Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Frontpanel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

6. Signal Generators and Analysis Instruments: Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator.Brief idea for testing, specifications. Distortion factor meter, wave analysis.

7. Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.

8. Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. 9. Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.

Suggested Experiments (at least five):

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.
9. Converting the range of a given measuring instrument (voltmeter, ammeter).

References/ Suggested Readings:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and □ design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3 rd Ed., 2012, Tata Mc-Graw Hill.
7. Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer.
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.

Semester-III

Major Course

Course Name: Mathematical Methods in Physics I

Course Code: BSCPHSMJ301

Course Type: Major (Theory)	Course Details: **MJC-3**			L-T-P: 4-**1-0**	
Credit: **5**	Full Marks: 10**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**30**	……	**70**

Course outcome: Students will have achieved the ability to:

1. Use concepts of calculus and concepts of random variables
2. Solve differential equations of various types.
3. Describe special functions and their recurrence relations
4. Do fourier expansion and use Fourier transforms and delta function
5. evaluate some special integrals

Course Content:

Theory

Module	Contents	Lec. (Hrs)
Calculus	Infinite sequences and series; Conditional and Absolute Convergence; Tests for Convergence (proofs not required), Functions of several real variables - partial differentiation, Constrained Maximization using Lagrange Multipliers.	10
Statistics	Random variables - joint and conditional probabilities,; Moments - mean, variance, skewness and curtosis, Examples of continuous probability distribution functions (Binomial, Gaussian, and Poisson). Citation of simple examples from Physics.	10

Determinant and Matrices	Basic idea of matrix algebra , Rank of a matrix; Solution of simultaneous equation of matrices by Cramer's rule; Solution of systems of linear homogenous and inhomogeneous equations by matrix method; Cayley-Hamilton theorem; Characteristics equation for a square matrix and diagonalization; Properties of Eigenvalues and eigenvectors of matrices; Symmetric, Skew- symmetric, Hermitian, Orthogonal and Unitary matrices and their properties.	10
Ordinary Differential Equations	Classifications of singularities for a Second Order Ordinary Differential Equation (ODE) - Fuchs' theorem; Series Solution of second order ODE with variable coefficients by Frobenius-Fuchs" method; Solutions of Legendre, Bessel and Hermite ODE. about x=0.	10
Partial Differential Equations	Partial Differential Equations in Physics; Types – elliptical, hyperbolic and parabolic (examples from Physics), Solutions by separation of variables method; Basic examples- Laplace's equation, Diffusion equation, Wave equation. Solution of Laplace's equation in Cartesian, spherical polar (spherically symmetric cases), and cylindrical polar (cylindrically symmetric problems) coordinate systems.	10
Special Functions	Properties of Legendre Polynomials: Rodrigues Formula, Generating Function. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality.	10
Some Special Integrals	Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.	5
Fourier Series and Transform	(a) Periodic functions in Physics, Dirichlet Conditions (Statement only). Wronskian of two functions - linear independence and completeness, orthogonality; Fourier series expansion of periodic functions in terms of sine and cosine as basis, Calculation of Fourier coefficients in some simple cases, Complex representation of Fourier series. Expansion of non-periodic functions, Even and odd functions as special cases. Applications in Physics – vibration of string. (b) Introduction of Fourier transform as Fourier series of infinite period, propeties of Fourier transform, Inverse Fourier transform, Parseval Identity. Dirac delta function and its important properties.	10

References/ Suggested Readings

1. Mathematical Methods in the Physical Sciences, Mary L. Boas
2. Essential Mathematical Methods for Physicists by Hans J. Weber and George B. Arfken
3. Introduction to Mathematical Physics - C. Harper (Prentice-Hall of India).
4. Mathematical Physics by Binoy Bhattacharya
5. Mathematical Physics by D. Biswas
6. Mathematical Physics by B S Grewal
7. Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill).
8. Mathematical Physics – P.K. Chattopadhyay (Wiley Eastern)

References/ Suggested Readings

1. Vector Analysis - M. R. Spiegel, (Schaum's Outline Series) (Tata McGraw-Hill)

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books Mathematical Physics by Binoy Bhattacharya
7. Mathematical Physics by D. Biswas
8. Mathematical Physics by B S Grewal
9. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
10. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
11. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge
University Press.
12. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
13. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006,Cambridge University Press.

MAJOR Course

Course Name : **OPTICS**

Course code: **BSCPHSMJ302**

<table>
<tr><td colspan="2">Course Type: Major (Theory and Practical)</td><td colspan="2">Course Details: MJC-4</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

Course Objective:-

This course reviews the concepts of waves and optics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of lens and different types of optical devices. The course also provides an in depth understanding of wave phenomena of light, namely, interference, diffraction and polarization with emphasis on practical applications of the same.

Course Learning Outcomes:

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

• Understand Interference as superposition of waves from coherent sources derived from same parent source.

• Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.

• In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc.

Course Content:

Theory

Module	Contents	Class Reqd. (Hrs)
Introduction to Geometrical Optics	Concept of ray, ray optics limit, geometrical and optical path, Fermat's Principle, Principle of least path and extremum paths-example of extremum path. Aplanatic surface, Application to laws of reflection and refraction for a) plane surface and b) spherical surface. Application to determine lens formula	**(4L)**
Matrix Method	Translation, refraction and reflection matrix. System matrix for thick and thin lenses. Cardinal points of optical system. Application to image formation by combination of two lenses. Concept of objective and eyepiece, Huygens Eyepiece and Ramsden Eyepiece as examples of lens combination, merits and demerits.	**(8L)**
Aberration	Seidal aberration and its different types. Its removal, Abbes Sine condition. Aplanatism and Aplanatic Surface. Its application to high power microscope objective. Chromatic aberration – longitudinal and transverse. Achromatism-achromatic doublet and separated doublet.	**(4L)**
Wave Motion	Plane Progressive elastic waves, Spherical and Cylindrical Waves; Longitudinal and Transverse Waves, Differential Equation for progressive wave (1d and 3d) and harmonic solutions, Relations among dilatation, condensation and excess pressure, Derivations of wave velocity of a longitudinal wave through an elastic medium and transverse wave through a string, Phase and Group velocity, Energy Transport associated with a Longitudinal Wave, Intensity of Wave. Definition and properties of wave front, Huygens Principle	**(8L)**
Interference of light waves	Definition and properties of wave front, Huygens Principle, Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring. Michelson's interferometer, Multiple beam interference – reflected and transmitted pattern. Fabry-Perot interferometer	**(7L)**

Diffraction of light waves	Fresnel and Fraunhofer class, Fresnel's half period zones; explanation of rectilinear propagation of light; zone plate. Fraunhofer diffraction due to a single slit, double slit and circular aperture (qualitative). Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating.	**(7L)**
Polarisation	Different states of polarisation; double refraction, Malus law, Huygen's construction for uniaxial crystals; polaroids and their uses. Lissajous Figures: Production and analysis of plane, circularly and elliptically polarised light by retardation plates and Babinet compensator; Rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter	**(7L)**

***References/ 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. Fundamental of optics, F. A. Jenkins & H. E. White, 1981, Tata McGraw hill.

7. Introduction To Optics- A.K. Ghatak

8. Optics- Hetch And Zajack.

9. A Textbook On Optics- B. Ghosh And K.G. Mazumdar.

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology,
https://openlearning.mit.edu/

2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd

Optics Lab [At least five experiments to be done]

1. To verify the law of Malus for plane polarized light.

2. To determine the specific rotation of sugar solution using polarimeter.

3. To analyze elliptically polarized light by using a Babinet‟s compensator.

4. Determination of angle of prism and to determine refractive index of the material of a prism using sodium source.

5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury/helium source.

6. To determine wavelength of sodium light using Fresnel biprism.

7. To determine wavelength of sodium light using Newton's rings.

8. To determine wavelength of (1) sodium source and (2) spectral lines of mercury/helium source using plane diffraction grating.

9. Determination of separation of D_1 and D_2 lines of sodium by using plane transmission grating.

10. Draw the calibration curve between μ and λ using mercury discharge tube and find out the unknown wavelength of a particular light.

11. Determination of grating element of a diffraction grating using a semiconductor laser.

12. Determination of wavelength of light using laser and single slit/wire.

SEMESTER: III

MINOR COURSE

Course Name: Fundamentals of Optics

Course code: **BSCPHSMN301**

Course Type: Minor (Theory and Practical)	Course Details: **MNC-3**			L-T-P: **3-0-4**	
Credit: **5**	Full Marks: 10**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	20	**35**

Course Objective:-

This course reviews the concepts of waves and optics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of lens and different types of optical devices. The course also provides an in depth understanding of wave phenomena of light, namely, interference, diffraction and polarization with emphasis on practical applications of the same.

Course Learning Outcomes:

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

• Understand Interference as superposition of waves from coherent sources derived from same parent source.

• Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.

• In the laboratory course, student will gain hands-on experience of using various optical instruments.

Course Content:

Theory

Module	**Contents**	**Class Reqd. (Hrs)**
Introduction to Geometrical Optics	Concept of ray, ray optics limit, geometrical and optical path, Fermat's Principle, Principle of least path and extremum paths-example of extremum path. Aplanatic surface, Application to laws of reflection and refraction for a) plane surface and b) spherical surface. Application to determine lens formula	**(5L)**

Waves	Plane Progressive elastic waves, Longitudinal and Transverse Waves, Differential Equation for 1d progressive wave and its solutions, Relations among dilatation, condensation and excess pressure, Derivations of wave velocity of a longitudinal wave through an elastic medium and transverse wave through a string, Phase and Group velocity, Energy Transport associated with a Longitudinal Wave, Intensity of Wave.	**(8L)**
Interference	Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring.	**(10L)**
Diffraction	Fresnel and Fraunhofer diffraction, Fraunhofer diffraction due to a single slit, double slit. Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism.	**(8L)**
Polarisation	Transverse nature of light waves. Different states of polarization; double refraction, retardation plates, Malus law, polaroids and their uses. polarizer and analyzer, Production and analysis of plane, circularly and elliptically polarized light, Rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter	**(7L)**
Laser, LED , and Optical Fiber	Spontaneous and stimulated emissions, Population inversion, theory of lasing action (Laser). Basic principle of LED , Characteristics and applications . Basic principle of optical fiber, Characteristics and applications. Numerical aperture.	**(7L)**

References/ Suggested Readings:

1. *Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill •*
2. *Principles of Optics, B.K. Mathur, 1995, Gopal Printing 16 •*
3. *Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication*
4. *UniversityPhysics.FWSears,MWZemanskyandHDYoung13/e, 1986.AddisonWesley*

WEB REFERENCES:

1. MIT Open Learning - Massachusetts Institute of Technology,
https://openlearning.mit.edu/

2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd

Fundamentals of Optics Lab [At least five experiments to be done]

1. To determine the focal length of a concave lens by combination method.
2. To determine the focal length of a concave lens by auxiliary method.
3. Determination of the refractive index of a liquid by using a plane mirror and a convex lens.
4. Determination of the refractive index of a water by using traveling microscope.
5. Determination of angle of prism and to determine refractive index of the material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury/helium source.
7. To determine wavelength of sodium light using Newton's rings.
8. Draw the calibration curve between μ and λ using mercury discharge tube and find out the unknown wavelength of a particular light.
9. Determination of grating element of a diffraction grating using a semiconductor laser / sodium source.
10. Determination of wavelength of light using laser and single slit/wire.
11. To determine the specific rotation of sugar solution using polarimeter.

SEM 3:

MD Course

Course Name: Indian Astronomy

Course code: **MDC-303**

Course Type: **MD (Theory)**	Course Details: MD - 3			L-T-P: 2-1-0=3	
Credit: 3	Full Marks: 50	CA Marks		ESE Marks	
			Theoretical		Theoretical
			15		**35**

Course Objective:-

Course Learning Outcomes:

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

•***Course Content:***

Theory

Module	Contents	Reqd. (Hrs)
Introduction to Indian Astronomy	**Historical Background**: **Vedic Period** **Rigveda**: Reference to celestial bodies and their movements. **Yajurveda and Atharvaveda**: References to the Sun, Moon, and stars. **Vedanga Jyotisha**: Early systematic approach to astronomy, focusing on the calendar and timekeeping. **Classical Period** **Aryabhata**: His heliocentric model, calculation of the Earth's circumference, and the concept of the Earth's rotation. **Varahamihira**: Contributions to meteorology, astrology, and his encyclopedic work, Brihat Samhita. **Medieval Period**: **Bhaskara II**: His work on calculus, accurate prediction of eclipses, and the Siddhanta Shiromani.	**(7L)**
Basic Concepts and Terminology	**Astronomical Units**: **Yojana**: Detailed explanation of its use in ancient texts and its approximate modern equivalent. **Nakshatra**: The 27 lunar mansions, their names, and significance in astrology and astronomy. **Kala, Kashta, and Nimesha**: Definitions and their use in timekeeping.	**(3L)**
Indian Astronomical Texts	**Siddhāntas**: **Surya Siddhanta**: Detailed contents, including planetary motion, eclipses, and timekeeping methods. **Aryabhatiya**: Aryabhata's contributions to mathematics and astronomy, such as his calculation of the value of pi and the concept of the Earth's rotation. **Brahmasphuta siddhanta**: Brahmagupta's work on algebra, his methods for solving quadratic equations, and his contributions to astronomy.	**(6L)**

Calendars and Time keeping	**Lunisolar Calendar**: **Structure**: Detailed explanation of the combination of lunar months and solar years in the Indian calendar. **Significance**: Importance of the lunisolar calendar in religious and agricultural activities. **Time Measurement**: **Tithi**: Definition and use of a lunar day in the calendar. **Nakshatra**: Description of the lunar mansions and their role in timekeeping. **Yoga**: Explanation of the combination of the Sun and Moon's positions and its significance.	**(6L)**
Modern Indian Astronomy	**Institutions**: Contributions of institutions like the Indian Institute of Astrophysics and the Inter-University Centre for Astronomy and Astrophysics, NCRA, GMRT, Radio Astronomy Center ,TIFR, ISRO etc **Key Researchers**: Notable modern Indian astronomers and their work; Meghnad Saha, Subhrmanyam Chandrasekhar, Nikhil Ranjan Sen, A. K. Roychowdhury, J. V. Narlikar. **ISRO's Space Missions**: Overview of missions like Chandrayaan, Mangalyaan, and their impact on astronomy.	**(8L)**

***References/ Suggested Readings*:**

1. Indian Astronomy, S. Balachandra Rao, University Press
2. NCERT book on Knowledge Traditions and Practices of India, Chapter-5
3. Astronomy in India A perspective, R. Kochar & J. Narlikar, Indian National Science Academy, new Delhi
4. Astronomy in India: A historical perspective, Thanu Padmanabham(Ed), Springer
5. Indian Astronomy, A Source Book, Compiled by B. V. Subbarayappa, and K. V. Sarma, Nehru Centre, Bombay(now Mumbai).

Semester-IV:

MAJOR COURSE

Course Name: Classical Mechanics and Special Theory of Relativity

Course Code: BSCPHSMJ401

Course Type: **Major (Theory and Practical)**	Course Details: **MJC-5**			L-T-P: 4**-1-0**	
Credit: **5**	Full Marks: 10**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**30**	……	**70**

Course Learning Outcomes:

After the completion of course, the students will have ability to:

1. Explain the classical mechanics of particle under central force.
2. Understand the Lagrangian and Hamiltonian formulations of classical mechanics.
3. Explain the necessity of replacing Newtonian relativity through Einstein's special relativity, concept of space-time and elaborate on the classical mechanics of fast particles under the special relativity.

Course Content:

Theory

Module	Contents	Class Reqd. (Hrs)
Central force Motion	Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram, Determination of orbits from central force and determination of central force from orbits.	**[10L]**
Constrained Motion	Constraints – Definition and classification with examples. Forces of constraint. Degrees of Freedom. Generalized coordinates. Virtual displacement and Principle of Virtual work. D'Alembert's principle and its applications in simple cases.	**[5L]**

Lagrangian Formulation	Lagrange's equation of motion from D'Alembert's principle and its application to simple cases. Comparison of Newtonian & Lagrangian formulations. Newton's equation of motion from Lagrange's equations. Generalized momenta and energy. Cyclic coordinates and its applications. Properties of kinetic energy function T, Ordinary potential energy function, Euler Lagrange equation of motion for conservative system.	**[10L]**
Hamiltonian Formulation	Hamilton's equations from Legendre's dual transformation to the Lagrangian of a system. Determination of Hamiltonian from Lagrangian for simple cases. Properties of the Hamiltonian and Hamilton's equations of motion. Application to simple systems. Configuration space, Phase space and State space. Homogeneity of time and conservation of energy; Homogeneity of space and conservation of linear momentum, Isotropy of space and conservation of angular momentum.	**[10L]**
Calculus of Variation.	Variational principle, Euler Lagrange equation of motion from variational principle, shortest distance between two points, Brachistochrone, Geodesic, Minimum surface of revolution. Hamilton's principle and its significance. Lagrange's equation and Hamilton's equations from Hamilton's principle.	**[10L]**
Canonical Transformations	Canonical transformations; Generating functions; examples of canonical transformations; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations.	**[10L]**
Small amplitude oscillations	Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of *N*identical masses connected in a linear fashion to (*N* -1) - identical springs.	**[5L]**

Special Theory of Relativity	Galilean Transformation.Non-invariance of Maxwell's equations under Galilean transformation. Michelson Morley experiment and its outcome. Steller aberration and Fizeau's experiment. Postulates of Special Theory of Relativity. Lorentz transformation-length contraction and time dilation. Relativity of simultaneity. Proper frame. Velocity addition formula. Relativistic mass and energy. Mass-energy equivalence. Energy-momentum relationship. Force and acceleration in relativity. Spacelike and timelike intervals. Twin paradox. Doppler effect (non- relativistic and relativistic).	**[10L]**

References/ Suggested Readings

1. *Classical Mechanics- H. Goldstein, C.P. Poole, J.L. Safko (Pearson Education)*
2. *Mechanics- L. D. Landau and E. M. Lifshitz (Pergamon)*
3. *Classical Mechanics- N. C. Rana and P. S. Joag (Tata McGraw-Hill).*
4. *Classical Mechanics- Gupta, Kumar, Sharma (Pragati Prakashan, Meerat)*
5. *Classical Mechanics: A Course of Lectures- A.K. Raychaudhuri (Oxford University Press)*
6. *Theoretical Mechanics- M.R. Spiegel (Tata McGraw Hill)*
7. *Introduction to Special Relativity- R. Resnick (John Wiley and Sons)*
8. *The Special Theory of Relativity- S. Banerji and A. Banerjee (Prentice Hall of India)*

Semester-IV

Course Name: Heat and Thermal Physics
Course Code: BSCPHSMJ402

Course Type: Major (Theory and Practical)	Course Details: **MJC-6**			L-T-P: **3-0-4**	
Credit: **5**	Full Marks: 10**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	20	**35**

Course Objective:-

Course Outcomes:

- Learn interrelation between pressure and molecular motion, and the concept of temperature as kinetic energy.
- Learn distribution of velocity, energy, their dependence on randomness of molecular motion, idea about dimension of molecules
- Learn about energy and momentum transport in gases
- Get the idea about the behaviours of real gases and intermolecular forces
- Can analyseone and three dimensional heat flow
- Learn about blackbody radiation and its applications.

Course Content:

Theory (45 Lectures)

Module	Contents	Class Reqd. (Hrs)
Kinetic Theory of Gases	**Growth of Kinetic Theory:** Basic assumptions of kinetic theory,Pressure exerted by ideal gas using concepts of spherical polar coordinates and solid angle, Deduction of perfect gas laws, concepts of temperature, rms speed, Avogardo's Hypothesis, Boltzman Constant. **Maxwell's velocity distribution law:** Maxwell's assumptions, derivation of the law, root mean square and most probable speeds. Experimental confirmation of the distribution law: Zartman and Ko method, Simpson and Ster's method, Richardson experiment. Reduced form of Maxwell's distribution, Energy distribution and momentum distribution, Dependence of the distribution on temperature and pressure of the gas. **Effect of finite size of molecules:** Collision probability, Mean free path, Distribution of free paths, derivation of mean free path using the concept of collision cross section, Clausius mean free path, correction by Maxwell(no derivation, only corrected expression). Experimental determination of mean free path by Born.	**(9 L)**
	Equipartition of energy: Degrees of freedom, mono, di and tri-atomic molecules, Equipartition of energy, Derivation using the concepts of Maxwell's energy distribution and taking energy as homogeneous function of position and momentum coordinates, applications of equipartition of energy to specific heat of gas and derivation of Doulong Petit's law. **Transport phenomena:** Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Interrelation between these coefficients and mean free path. **Experimental evidence of molecular motion:** Brownian motion, Special features, Distribution of pressure in a vertical column of gas in equilibrium under gravity and derivation of particle distribution, modification due to modification of mass of Brownian particle due to Buoyancy, Concept of determination of Avogadro's number using Brownian motion.	**(8L)**

Equation of state for Real Gases	**Experimental Background:** Insufficiency of ideal gas equation, Amagat's experiment, Virial equation of state and Boyle temperature, Andrews' experiment and concept of critical temperature, state of matter near critical point, van der-Waals equation of state. **DIscussion on van der Wall's equation:** Roots of van der Wall's equations, isotherms from van der wall's equation, Critical Constants, Reduced equation of state and law of corresponding state, critical coefficient, critical coefficient of a gas, law of corresponding states; Virial Coefficients, Boyle temperature. **Other equations of state:** Defects of van der Wall's equation, Clausius equation, Dieterici's equation and Barthelot'sequation(no derivation of any of these equations is required).	**(8L)**
Conduction of Heat	Difference between conduction and other processes of heat transfer, dependence of rate of heat conduction on structure and property of the medium and idea of thermal conductivity. **1L** **One dimensional heat flow:**Mathematical theory of heat conduction and Fourier's equation for one dimensional heat flow, thermal and thermometric conductivity, solution for of Fourier's equation for rectilinear flow of heat, Ingen Hausz's experiment, freezing of pond and heat conduction through composite slab, Periodic flow of heat, conductivity of earth's crust. **Three dimensional heat flow:** spherical and cylindrical flow of heat, Wideman- Franz law(statement and discussion).	**(10L)**
Radiation	**Source of thermal radiation:** Material radiation and energy radiation examples, similarities of thermal radiation and light, Blackbody, Spectral emissive and absorptive powers, total emission from an elementary area, Kirchoff's law, Ritche's experiment, properties of blackbody radiation,Total energy of radiation, Stefan-Boltzmann law, Newton's law of cooling, Determination of Stephan's constant by hemispherical blackbody and thermocouple. **Energy distribution in the blackbody:** Wien's law, Rayleigh-Jeans formula, ultraviolet catastrophe, Planck's law, and deduction of Wien's law, Rayleigh Jeans law and Stephan's constant from Planck's law, Temperature of the Sun from Plank's law and Wien's law. **Radiation pyrometer:** Basic principle based on Stephan's law.	**(10L)**

***Books Recommended**:*

1. *P K Chakraborty, Thermal Physics, Sreedhar Publications*
2. *Roy and Gupta, Thermal Physics, Books and Allied.*
3. *Garg, Bansal, and Ghosh, Thermal Physics, 2nd Ed, Mac Graw Hill.*

***Reference Books**:*

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, McGraw-Hill.
2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, Indian Press
3. Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. Narosa.
4. Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, S. Chand publications

Heat and Thermal Physics - Lab (at least 5 experiments are to be done)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
4. To determine the Temperature Coefficient of Resistance of platinum by Platinum Resistance Thermometer
5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
6. To determine temperature coefficient of resistance by meter-bridge.
7. Determination of coefficient of linear expansion by optical lever.
8. Determination of coefficient of linear expansion by Pullinger's apparatus
9. Determination of pressure coefficient of air by Jolly's apparatus.
10. To determine the Coefficient of Thermal Conductivity of Cu by Searle"s Apparatus.
11. To study the variation of Thermo-emf of a Thermocouple with Difference ofTemperature of its Two Junctions using a null method.

Syllabus (Semester IV)

Course type: **MINOR** Course

Course Name: **Fundamentals of Thermal Physics**

Course **Code: BSCPHSMN401**

Course Type: **Minor (Theory and Practical)**	Course Details: **MNC-4**			L-T-P: **3-0-4**	
Credit: **5**	Full Marks: 10**0**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**15**	20	**35**

Course Objective:-

Course Outcomes:

- Learn interrelation between pressure and molecular motion, and the concept of temperature as kinetic energy.
- Learn distribution of velocity, energy, their dependence on randomness of molecular motion, idea about dimension of molecules .
- Learn about energy and momentum transport in gases Get the idea about the behaviors of real gases and intermolecular forces.
- Learn about blackbody radiation and its applications.

Course Content:

Theory

Module	**Contents**	**Class Reqd. (Hrs)**

Kinetic Theory of Gases	**Growth of Kinetic Theory:** Basic assumptions of kinetic theory,Pressure exerted by ideal gas using concepts of spherical polar coordinates and solid angle, Deduction of perfect gas laws, concepts of temperature, rms speed, Avogardo's Hypothesis, Boltzman Constant. **Maxwell's velocity distribution law:** Maxwell's assumptions, derivation of the law, root mean square and most probable speeds. Experimental confirmation of the distribution law: Zartman and Ko method, **Effect of finite size of molecules:** Collision probability, Mean free path, Distribution of free paths, derivation of mean free path using the concept of collision cross section, Clausius mean free path, correction by Maxwell (no derivation, only corrected expression). **Real gas :** Deviation from ideal behaviour. Vander Waal's equation of state, critical constant from P-V isotherms	**(8L)**
	Equipartition of energy: Degrees of freedom, mono, di and tri-atomic molecules, Equipartition of energy (no derivation), applications of equipartition of energy to specific heat of gas and derivation of DoulongPetit's law. **Transport phenomena:** Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Interrelation between these coefficients and mean free path. **Experimental evidence of molecular motion:** Brownian motion, Special features, Distribution of pressure in a vertical column of gas in equilibrium under gravity and derivation of particle distribution, Concept of determination of Avogadro's number using Brownian motion.	**(6L)**
Conduction of Heat	**One dimensional heat flow:** Mathematical theory of heat conduction and Fourier's equation for one dimensional heat flow, thermal and thermometric conductivity, solution for of Fourier's equation for rectilinear flow of heat, Ingen Hausz's experiment, Periodic flow of heat, conductivity of earth's crust (no derivation) **Three dimensional heat flow:** spherical and cylindrical flow of heat, Wideman- Franz law (statement and discussion).	**(6L)**
Radiation	**Source of thermal radiation:** Material radiation and energy radiation examples, similarities of thermal radiation and light, Blackbody, Spectral emissive and absorptive powers, total emission from an elementary area, Kirchoff's law, properties of blackbody radiation, Total energy of radiation, Stefan-Boltzmann law, Newton's law of cooling. **Energy distribution in the blackbody:** Wien's law, Rayleigh-Jeans formula, ultraviolet catastrophe, Planck's law. **Radiation pyrometer:** Basic principle based on Stephan's law.	**(7L)**

Thermodynamics	Laws of Thermodynamics: Thermodynamic Description of system, Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P & C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility &Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Un attainability of absolute zero.	**10L**
Statistical Mechanics	Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Boltman entropy relation, Maxwell-Boltzmann distribution from entropy maximization. Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics (Derivation not required) Qualitative discussion on Fermi Level, B-E Condensation.	(**8L**)

***Books Recommended**:*

1. *P K Chakraborty, Thermal Physics, Sreedhar Prakashani*
2. *Roy and Gupta, Thermal Physics, Books Allied.*
3. *Garg, Bansal, and Ghosh, Thermal Physics, 2nd Ed, Mac Graw Hill.*
4. *Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, 1st Edn., 2008, S. Chand.*

Heat and Thermal Physics - Lab [Marks: 50]

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
4. To determine the Temperature Coefficient of Resistance of platinum by Platinum Resistance Thermometer

5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
6. To determine temperature coefficient of resistance by meter-bridge.
7. Determination of coefficient of linear expansion by optical lever.
8. Determination of coefficient of linear expansion by Pullinger's apparatus
9. Determination of pressure coefficient of air by Jolly's apparatus.
10. To determine the Coefficient of Thermal Conductivity of Cu by Searle"s Apparatus.
11. To study the variation of Thermo-emf of a Thermocouple with Difference ofTemperature of its Two Junctions using a null method.

SKILL ENHANCEMENT COURSE

(Evaluation is to be done internally)

Course Name: Computer Oriented Numerical Analysis

Course Code: BSCPHSSE401

Course Type: **SEC(Practical)**	Course Details: **SEC-3**			L-T-P: **0-0-6**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	…….	20	……

Course Learning Outcomes:

After the completion of course, the students will have ability to:

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1. Numerical Differentiation and Integration: Trapezoidal and Simpson's 1/3 rd rule and 3/5 th rule, Gauss method, Error propagation. Fourier Series and Fast Fourier Transform. Analysis of Noise from Physical and Physiological (cardiac signal) data.

2. Solution of Algebraic and Transcendental equations: methods of Bisection, Newton Raphson, Regula falsi, Matrix Inversion. Solution of linear and quadratic equation.

3. Solution of Linear system of equations: Gauss elimination method-Pivortal condensation, Gauss Seidal method. Electrical Circuit analysis using Kirchhoff's law

4. Solution of 1st order and 2nd order ODE: Euler, Heun's, Polygon, Runge-Kutta 4th order methods, Predictor Corrector, finite difference method. Applications to Physics Problems linear and nonlinear oscillators – free, damped, forced, bifurcation and chaos in atmospheric, epidemic and sociological models.

5. Curve fitting: Least square fit- linear and quadratic regression, exponential and logarithmic fit. Goodness of fit, standard deviation. Applications: Ohms law to calculate R, Hooke's law to calculate spring constant.

6. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems : Solution ofmesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses).

7. Other applications in mathematical modelling in Physics using numerical analysis and associated techniques.

References/ Suggested Readings:

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.

2. Schaum‟s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A

Poe, 1986Mc-Graw Hill Book Co.

3. Computational Physics: An Introduction, R. C. Verma, et al. New Age International

Publishers, New Delhi (1999)

4. Computer Oriented Numerical analysis by V. Rajaraman.

4. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning

5. Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn. , 2007, Wiley India.

6. Numerical Methods by S.A. Molla.

7. *Computation Physics: Problem Solving with Python, 3rd Edition by Rubin H. Landau, Manuel J Páez, Cristian C. Bordeianu.*

9. *Computational Physics by N.H.Giordano and H. Nakanishi, Person.*

SKILL ENHANCEMENT COURSE

(Evaluation is to be done internally)

Course Name: Scientific writing and Documentation

Course Code: BSCPHSSE402

Course Type: **SEC(Practical)**	Course Details: **SEC-3**			L-T-P: **0-0-6**	
Credit: **3**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	…….	20	……

Course Learning Outcomes:

After the completion of course, the students will have ability to:

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Course Content:

1. Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages.

Equation representation: Formulae and equations, Figures and other floating bodies, Lining in

columns- Tabbing and tabular environment, Generating table of contents, bibliography and

citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

2. Handling with Excel: basic cell management, use of functions, control to different sheet.

3. Plotting with graphical software: Use of gnuplot / Origin for plotting functions and data for graphical visualization (2D and 3D). Curve fitting: Linear least square fitting of data. Plotting data from a data file, plotting functions (inbuilt), histograms, and graphs, overlapping plots, least square fit of data points, Generation of pseudo-random numbers using inbuilt functions and plot frequency distribution. Use Plotting functions (inbuilt) for MATLAB and matplotlib LIBRARY for PYTHON (if applicable).

References/ Suggested Readings:

1. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley,

1994).

2. Modelling with Microsoft Excel by B.V.Liengme.

3. LateX in 24 hours: A practical guide for scientific writing by Dilip Dutta, Springer

International Publishing.

4. Gnuplot 5.2 Manual : An Interactive Plotting Program by Thomas Williams and Colin Kelly,

(2017).