

# **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: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	<b>15</b>	20	<b>35</b>

### **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) gravitational, (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 Coordinate & 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;

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

### **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/courses>  
<https://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, 1 <sup>st</sup> Edition, | D P Khandelwal  | Vikas Publications.                 |
| 3. B.Sc. Practical Physics (Revised Edition)  |   | S.Chand& Co.                        |
| 4. An advanced course in practical physics.   | C. L Arora<br>D. Chatopadhyay, PC<br>Rakshit, B. Saha | New Central Book<br>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			
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10. *Classical Mechanics by Rana Joag*
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| 4. An advanced course in practical physics.   | C. L Arora<br>D. Chatopadhyay, PC<br>Rakshit, B. Saha | New Central Book<br>Agency Pvt Ltd. |

## MD COURSE

**COURSE NAME: PHYSICAL SCIENCE**

**COURSE CODE: MDC101**

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

### **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: 50	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):

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

#### **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 equations 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 (determination 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 <b>(Theory and Practical)</b>	Course Details: MNC-2		L-T-P: 3-0-4		
Credit: 5	Full Marks: <b>100</b>	CA Marks		ESE Marks	
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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 (determination of  $\frac{dB}{dx}$ ).

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.

## 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. AC Electricity 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 phasor 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 phasor 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: (Practical)	SEC	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 rectifier amplifier. 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  $\square$  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: <b>MJC-3</b>			L-T-P: <b>4-1-0</b>	
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	<b>30</b>	.....	<b>70</b>

**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**

<b>Module</b>	<b>Contents</b>	<b>Lec. (Hrs)</b>
<b>Calculus</b>	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
<b>Statistics</b>	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
<b>Determinant and Matrices</b>	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
<b>Ordinary Differential Equations</b>	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
<b>Partial Differential Equations</b>	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
<b>Special Functions</b>	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
<b>Some Special Integrals</b>	Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.	5

<b>Fourier Series and Transform</b>	<p>(a) Periodic functions in Physics, Dirichlet Conditions (Statement only). Wronskian of two functions - linear independence and completeness, orthogonality;</p> <p>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.</p> <p>(b) Introduction of Fourier transform as Fourier series of infinite period, properties of Fourier transform, Inverse Fourier transform, Parseval Identity. Dirac delta function and its important properties.</p>	10
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### **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. Press et al, 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**

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

### 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 Fraunhofer 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)
<b>Introduction to Geometrical Optics</b>	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	<b>(4L)</b>
<b>Matrix Method</b>	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.	<b>(8L)</b>
<b>Aberration</b>	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.	<b>(4L)</b>

<b>Wave Motion</b>	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	<b>(8L)</b>
<b>Interference of light waves</b>	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	<b>(7L)</b>
<b>Diffraction of light waves</b>	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.	<b>(7L)</b>
<b>Polarisation</b>	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	<b>(7L)</b>

**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<sub>1</sub> and D<sub>2</sub> lines of sodium by using plane transmission grating.
10. Draw the calibration curve between  $\mu$  and  $\lambda$  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**

<b>Course Type: Minor (Theory and Practical)</b>	<b>Course Details: MNC-3</b>			<b>L-T-P: 3-0-4</b>	
<b>Credit: 5</b>	<b>Full Marks: 100</b>	<b>CA Marks</b>		<b>ESE Marks</b>	
		<b>Practical</b>	<b>Theoretical</b>	<b>Practical</b>	<b>Theoretical</b>
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

**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 Fraunhofer and Fresnel Diffraction.
- In the laboratory course, student will gain hands-on experience of using various optical instruments.

**Course Content:**

**Theory**

<b>Module</b>	<b>Contents</b>	<b>Class Reqd. (Hrs)</b>
<b>Introduction to Geometrical Optics</b>	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	<b>(5L)</b>
<b>Waves</b>	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.	<b>(8L)</b>
<b>Interference</b>	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.	<b>(10L)</b>
<b>Diffraction</b>	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.	<b>(8L)</b>
<b>Polarisation</b>	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	<b>(7L)</b>
<b>Laser, LED, and Optical Fiber</b>	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.	<b>(7L)</b>

**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. *University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison Wesley*

**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  $\mu$  and  $\lambda$  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: <b>MD (Theory)</b>	Course Details: MD - 3		L-T-P: 2-1-0=3		
Credit: 3	Full Marks: 50	CA Marks		ESE Marks	
			Theoretical		Theoretical
			<b>15</b>		<b>35</b>

**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**

<b>Module</b>	<b>Contents</b>	<b>Reqd. (Hrs)</b>
Introduction to Indian Astronomy	<p style="text-align: center;"><b>Historical Background:</b></p> <p style="text-align: center;"><b>Vedic Period</b>  <b>Rigveda:</b> Reference to celestial bodies and their movements.  <b>Yajurveda and Atharvaveda:</b> References to the Sun, Moon, and stars.  <b>Vedanga Jyotisha:</b> Early systematic approach to astronomy, focusing on the calendar and timekeeping.</p> <p style="text-align: center;"><b>Classical Period</b>  <b>Aryabhata:</b> His heliocentric model, calculation of the Earth’s circumference, and the concept of the Earth’s rotation.  <b>Varahamihira:</b> Contributions to meteorology, astrology, and his encyclopedic work, Brihat Samhita.</p> <p style="text-align: center;"><b>Medieval Period:</b>  <b>Bhaskara II:</b> His work on calculus, accurate prediction of eclipses, and the Siddhanta Shiromani.</p>	(7L)
<b>Basic Concepts and Terminology</b>	<p style="text-align: center;"><b>Astronomical Units:</b></p> <p><b>Yojana:</b> Detailed explanation of its use in ancient texts and its approximate modern equivalent.  <b>Nakshatra:</b> The 27 lunar mansions, their names, and significance in astrology and astronomy.  <b>Kala, Kashta, and Nimesha:</b> Definitions and their use in timekeeping.</p>	(3L)

<b>Indian Astronomical Texts</b>	<p style="text-align: center;"><b>Siddhāntas:</b></p> <p><b>Surya Siddhanta:</b> Detailed contents, including planetary motion, eclipses, and timekeeping methods.</p> <p><b>Aryabhatiya:</b> Aryabhata’s contributions to mathematics and astronomy, such as his calculation of the value of pi and the concept of the Earth’s rotation.</p> <p><b>Brahmasphuta siddhanta:</b> Brahmagupta’s work on algebra, his methods for solving quadratic equations, and his contributions to astronomy.</p>	<b>(6L)</b>
<b>Calendars and Time keeping</b>	<p style="text-align: center;"><b>Lunisolar Calendar:</b></p> <p><b>Structure:</b> Detailed explanation of the combination of lunar months and solar years in the Indian calendar.</p> <p><b>Significance:</b> Importance of the lunisolar calendar in religious and agricultural activities.</p> <p style="text-align: center;"><b>Time Measurement:</b></p> <p><b>Tithi:</b> Definition and use of a lunar day in the calendar.</p> <p><b>Nakshatra:</b> Description of the lunar mansions and their role in timekeeping.</p> <p><b>Yoga:</b> Explanation of the combination of the Sun and Moon’s positions and its significance.</p>	<b>(6L)</b>
<b>Modern Indian Astronomy</b>	<p><b>Institutions:</b> 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</p> <p><b>Key Researchers:</b> Notable modern Indian astronomers and their work; Meghnad Saha, Subhrmanyam Chandrasekhar, Nikhil Ranjan Sen, A. K. Roychowdhury, J. V. Narlikar.</p> <p><b>ISRO’s Space Missions:</b> Overview of missions like Chandrayaan, Mangalyaan, and their impact on astronomy.</p>	<b>(8L)</b>

***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: <b>Major (Theory and Practical)</b>	Course Details: <b>MJC-5</b>	L-T-P: <b>4-1-0</b>			
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	<b>30</b>	.....	<b>70</b>

#### **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**

<b>Module</b>	<b>Contents</b>	<b>Class Reqd. (Hrs)</b>
<b>Central force Motion</b>	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.	<b>[10L]</b>
<b>Constrained Motion</b>	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.	<b>[5L]</b>
<b>Lagrangian Formulation</b>	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.	<b>[10L]</b>
<b>Hamiltonian Formulation</b>	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.	<b>[10L]</b>
<b>Calculus of Variation.</b>	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.	<b>[10L]</b>

<b>Canonical Transformations</b>	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.	<b>[10L]</b>
<b>Small amplitude oscillations</b>	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.	<b>[5L]</b>
<b>Special Theory of Relativity</b>	Galilean Transformation. Non-invariance of Maxwell's equations under Galilean transformation. Michelson Morley experiment and its outcome. Stellar 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).	<b>[10L]</b>

### **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: <b>MJC-6</b>			L-T-P: <b>3-0-4</b>	
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

### 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 analyse one and three dimensional heat flow
- Learn about blackbody radiation and its applications.

***Course Content:***

**Theory (45 Lectures)**

Module	Contents	Class Reqd. (Hrs)
<b>Kinetic Theory of Gases</b>	<p><b>Growth of Kinetic Theory:</b> 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, Avogadro's Hypothesis, Boltzmann Constant.</p> <p><b>Maxwell's velocity distribution law:</b> Maxwell's assumptions, derivation of the law, root mean square and most probable speeds.</p> <p>Experimental confirmation of the distribution law: Zartman and Ko method, Simpson and Stern'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.</p> <p><b>Effect of finite size of molecules:</b> 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.</p>	<b>(9 L)</b>
	<p><b>Equipartition of energy:</b> 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 Dulong Petit's law.</p> <p><b>Transport phenomena:</b> Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Interrelation between these coefficients and mean free path.</p> <p><b>Experimental evidence of molecular motion:</b> 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.</p>	<b>(8L)</b>

<p><b>Equation of state for Real Gases</b></p>	<p><b>Experimental Background:</b> 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.</p> <p><b>Discussion on van der Wall's equation:</b> 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.</p> <p><b>Other equations of state:</b> Defects of van der Wall's equation, Clausius equation, Dieterici's equation and Barthelot's equation(no derivation of any of these equations is required).</p>	<p><b>(8L)</b></p>
<p><b>Conduction of Heat</b></p>	<p>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. <b>1L</b></p> <p><b>One dimensional heat flow:</b>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.</p> <p><b>Three dimensional heat flow:</b> spherical and cylindrical flow of heat, Wide-man- Franz law(statement and discussion).</p>	<p><b>(10L)</b></p>
<p><b>Radiation</b></p>	<p><b>Source of thermal radiation:</b> 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.</p> <p><b>Energy distribution in the blackbody:</b> 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.</p> <p><b>Radiation pyrometer:</b> Basic principle based on Stephan's law.</p>	<p><b>(10L)</b></p>

**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 of Temperature 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: <b>Minor</b> <b>(Theory and Practical)</b>	Course Details: <b>MNC-4</b>		L-T-P: <b>3-0-4</b>		
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

**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)
<b>Kinetic Theory of Gases</b>	<p><b>Growth of Kinetic Theory:</b> 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, Avogadro's Hypothesis, Boltzmann Constant.</p> <p><b>Maxwell's velocity distribution law:</b> Maxwell's assumptions, derivation of the law, root mean square and most probable speeds.</p> <p>Experimental confirmation of the distribution law: Zartman and Ko method,</p> <p><b>Effect of finite size of molecules:</b> 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).</p> <p><b>Real gas :</b> Deviation from ideal behaviour. Vander Waal's equation of state, critical constant from P-V isotherms</p>	<b>(8L)</b>
	<p><b>Equipartition of energy:</b> 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 DulongPetit's law.</p> <p><b>Transport phenomena:</b> Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Interrelation between these coefficients and mean free path.</p> <p><b>Experimental evidence of molecular motion:</b> 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.</p>	<b>(6L)</b>
<b>Conduction of Heat</b>	<p><b>One dimensional heat flow:</b> 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)</p> <p><b>Three dimensional heat flow:</b> spherical and cylindrical flow of heat, Wideman-Franz law (statement and discussion).</p>	<b>(6L)</b>

<b>Radiation</b>	<p><b>Source of thermal radiation:</b> 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.</p> <p><b>Energy distribution in the blackbody:</b> Wien's law, Rayleigh-Jeans formula, ultraviolet catastrophe, Planck's law.</p> <p><b>Radiation pyrometer:</b> Basic principle based on Stephan's law.</p>	<b>(7L)</b>
<b>Thermodynamics</b>	<p>Laws of Thermodynamics: Thermodynamic Description of system, Zero<sup>th</sup> 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 <math>C_P</math> &amp; <math>C_V</math>, Work Done during Isothermal and Adiabatic Processes, Compressibility &amp; Expansion Coefficient, Reversible &amp; irreversible processes, Second law &amp; Entropy, Carnot's cycle &amp; theorem, Entropy changes in reversible &amp; irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Un attainability of absolute zero.</p>	<b>10L</b>
<b>Statistical Mechanics</b>	<p>Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Boltzman entropy relation, Maxwell-Boltzmann distribution from entropy maximization.</p> <p>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.</p>	<b>(8L)</b>

**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 of Temperature 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: <b>SEC(Practical)</b>	Course Details: <b>SEC-3</b>	L-T-P: <b>0-0-6</b>
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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:

- to understand and apply various numerical methods,
- implement them using computers, analyze errors, and understand the underlying mathematical principles.
- They should also be able to solve a variety of problems, including those involving algebraic and differential equations, interpolation, and integration.

**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-Pivotal 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 of mesh 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: <b>SEC(Practical)</b>	Course Details: <b>SEC-3</b>	L-T-P: <b>0-0-6</b>	
		CA Marks	ESE Marks

Credit: <b>3</b>	Full Marks: <b>50</b>	Practical	Theoretical	Practical	Theoretical
		30	.....	20	.....

**Course Learning Outcomes:**

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

- to present data.
- analyse and review scientific manuscripts for key messages, consistency and justification.
- understand the importance of informal peer review and feedback.
- share and build on the existing scientific knowledge of a field.

**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).

### Semester-IV:

**Course Type : MAJOR COURSE**

**Course Name : Analog Electronics**

**Course Code : BSCPHSMJ501**

Course Type: <b>MJC-7</b>	Course Details: <b>Analog Electronics</b>		L-T-P: <b>3-0-4</b>		
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

#### **Course Learning Outcomes:**

*The course will enable the students to acquire necessary knowledge on semiconductor elements. With the knowledge of basic electronics, a student will understand the basic principles of the electrical or electronic circuits encountered in our daily life. They will acquire necessary hands-on experience on some widely used electronic circuits.*

#### **Course Content:**

##### **Theory**

**1. Semiconductor Physics:** Energy Band in Solids: Classification of Metal, Insulator and Semiconductor, Intrinsic and Extrinsic Semiconductor, N-type and P-type semiconductor, Current conduction in semiconductors- Drift and Diffusion, Conductivity and Mobility, Effects of temperature on Conductivity of semiconductor.

[3L]

**2. Semiconductor Diodes and applications:** PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation

for Barrier Potential, Barrier Width and Current for Step Junction. Zener Diode and Voltage Regulation. Principle and structure of Light Emitting Diode, Photodiode, Varactor diode, Schottky diode and Solar Cell. Half-wave rectifiers, Centre-tapped and Bridge Full-wave Rectifiers. Calculation of Ripple Factor and Rectification Efficiency. Basic idea of C-filter. Clipping and Clamping Circuit.

[8L]

### 3. Bipolar and Unipolar Junction transistors

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Early effect. Current gains  $\alpha$  and  $\beta$ , Relations between  $\alpha$  and  $\beta$ . Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. Basic structure and principle of operations of FET and their characteristics.

[11L]

**4. BJT based Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias, Voltage Divider Bias, Emitter bias and collector to base bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model: Input and Output Impedance. Current, Voltage and Power Gains. Frequency response of a CE amplifier. Comparative study of CB, CC and CE configurations. Class A, B & C Amplifiers. Class-B Push-pull amplifier.

[8L]

**6. Coupled Amplifier:** Two stage RC-coupled amplifier (analysis of single stage only).

[2L]

**7. Feedback in Amplifiers:** Principle of feedback. Types of feedback connection. Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

[3L]

**8. Operational Amplifiers (Black Box approach):** Characteristics of an Ideal and Practical Operational Amplifier (IC 741). Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Logarithmic amplifier, (5) Zero crossing detector, (6) Differentiator and (7) Integrator. Voltage to Current converter and Current to Voltage converter.

[9L]

**9. Sinusoidal Oscillators:** Introduction to Oscillators, Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Wein bridge oscillator, Hartley & Colpitts oscillators.

[4L]

## Practical

### (Minimum 5 Experiments are to be performed)

1. To study the V-I characteristics of PN junction diode and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the static characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study frequency response of CE transistor amplifier of a given mid-gain using voltage divider bias.
5. To study the frequency response of voltage gain of a RC-coupled transistor amplifier for two different loads.
6. To design an inverting amplifier using Op-amp (741/351) for dc voltage of given gain.
7. To design inverting amplifier using Op-amp (741/351) and study its frequency response.
8. To design non-inverting amplifier using Op-amp (741/351) & study its frequency response.
9. To add two dc voltages using Op-amp in inverting and non-inverting mode.

10. To investigate the use of an Op-amp as an Integrator and as a differentiator.

**References/ Suggested Readings**

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic Circuits, A. S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
11. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
12. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
13. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
14. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

**Course Type: MAJOR**

**Course Name : Quantum Mechanics-I**

**Course Code: BSCPHYMJ502**

Course Type: <b>MJC-8</b>	Course Details: <b>Quantum Mechanics-I</b>		L-T-P: <b>3-0-4</b>		
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	<b>15</b>	20	<b>35</b>

**Course Learning Outcomes:** *After the completion of course, the students will have ability to:*

1. *Explain the failures of classical theory in explaining different experiments of early twentieth century are discussed.*
2. *Understand ideas of wave-particle duality, matter-wave.*
3. *Explain how the importance of Schrodinger equation (time-dependent and time-independent) to demonstrate solutions of some systems for different proto-type potentials (1d and 3d) .*
4. *Understand the concepts of quantum (hermitian) operators and basis vectors.*

**Course Content:**

**Theory (Total Lecture: 45 )**

Module	Contents	Lecture (Hrs)
<i>Failures of Classical Theory</i>	Ultraviolet catastrophe-Planck's formula of black-body radiation and its asymptotic limits, Photoelectric effect, Compton effect, Atomic levels -quantization of energy levels (Qualitative idea with Bohr-Sommerfeld model).	3
<i>Basics of new ideas</i>	(a) Wave-particle duality -de Broglie hypothesis, Double-slit experiment with electron source, Davisson-Germer experiment, Statement of Heisenberg's uncertainty principle (thought experiments and applications), Group and Phase velocity of matter wave (with non-relativistic and relativistic dispersion). Principle of superposition – idea of wave function.	5
	(b) Development of the Schrodinger equation in position space, Stationary states, Time dependent and time independent Schrodinger equation, Probabilistic interpretation; equation of continuity, probability current density. Boundary conditions on the wave function.	3
<i>Theoretical formulation</i>	(a) Linear hermitian operators and their eigenvalue equations; Idea of hermitian operators for quantum dynamical variables, examples-momentum, position, hamiltonian (energy) and angular momentum operators.	12
	(b) Commutation relations- e.g., $[x,p]$ , $[L_i, L_j]$ Compatible observables and simultaneous measurements, Ehrenfest theorem.	
<i>Applications of Quantum</i>	(a) Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle.	12

*Mechanics  
(1D problems)*

(b) 1D potential well and potential barrier, boundary conditions, bound and unbound states.

Particle within an infinite potential 1D box with  $[0,L]$  or  $[-L,L]$  boundaries. Parity of the solutions.

Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha-decay.

(c) Linear Harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function.

Applications of  
Quantum  
Mechanics (3D  
problems)

(a) Particle confined into rectangular box with infinite potential boundaries – periodic boundary condition.

10

(b) Schrodinger equation in spherical polar coordinates; Radial and Azimuthal equations, The hydrogen atom–stationary state wavefunctions as simultaneous eigenfunctions of  $H$ ,  $L^2$  and  $L_z$ ; radial wavefunctions and eigen energy (Laguerre polynomial solutions to be assumed).

### **References/ Suggested Readings:**

1. *Introduction to Quantum Mechanics (2nd Edition)* by David J. Griffiths
2. *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2ed* by Robert Eisberg, Robert Resnick
3. *A Textbook Of Quantum Mechanics 2/E* by P M Mathews and K Venkatesan
4. *Quantum Mechanics: Theory and Applications* by Ajoy Ghatak and S. Lokanathan
5. *Introductory Quantum Mechanics* by S. N. Ghoshal
6. *Modern Physics* by A. Beiser

### **Quantum Mechanics Lab (FM-50)**

#### **Minimum five experiments are to be performed**

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photoelectrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the ionization potential of mercury.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.

7. To determine the value of  $e/m$  by (a) Magnetic focusing or (b) Bar magnet.
8. Frank-Hertz experiment.

**Course Type: MAJOR**

**Course Name: Electromagnetic Theory & its Applications**

**Course Code: BSCPHSMJ503**

Course Type: <b>MJC-9</b>	Course Details: <b>Electromagnetic Theory &amp; its Applications</b>			L-T-P: <b>4-1-0</b>	
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		--	<b>30</b>	--	<b>70</b>

**Course Learning Outcomes:**

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

1. *Demonstrates the theory behind the generation of the electromagnetic (transverse) progressive wave in combination of oscillating electric and magnetic fields.*
2. *Understand the basics of electromagnetic wave and its propagation through conducting and non-conducting medium and their application in modern day communication system.*
3. *Understand the theories of the manifestations by EM wave (viz., dispersion, scattering, polarisation).*

**Course Content:**  
**Theory**

**1. Time Varying Fields and Maxwell's Equations:**

Continuity equation, Displacement current; Maxwell's equations, Vector and Scalar potentials, Boundary conditions for Electromagnetic (EM) fields; Gauge transformation: Lorentz and Coulomb Gauge; Poynting vector and Poynting's theorem; EM energy density [10L]

**2. EM Wave Propagation in Unbounded Media:**

2.1. Wave equation in isotropic dielectric medium, Speed of EM wave, Refractive index and dielectric constant, Plane EM wave in free space and in isotropic dielectric medium, Transverse nature of plane EM waves

2.2. Wave equation in conducting media, Plane wave solutions, Skin effect. [12L]

### 3. EM Wave Propagation in Bounded Media:

3.1. 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, Change of phase on reflection, Brewster's law. Reflection & Transmission coefficients. Total internal reflection

3.2. Reflection and Transmission of plane EM wave at a conducting surface [14L]

4. **Wave guide:** Propagation of electromagnetic waves between parallel conducting plates – Wave guides with rectangular cross-sections; TE and TM modes [10L]

5. **Optical fibres:** Total internal reflection; Optical fibre as wave-guide, Acceptance angle and Numerical Aperture; Step index and Graded index fibres [4L]

6. **Dispersion:** Normal and Anomalous Dispersions; Sellmeier's and Cauchy's formulae from electromagnetic theory [4L]

7. **Scattering:** Scattering of radiation by a free electron (Thomson scattering), Scattering of radiation by a bound electron (Rayleigh scattering), Differential scattering cross-section [Derivation not required] [10L]

### References/ Suggested Readings :

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Classical Electrodynamics, J D Jackson, John Wiley.
3. Elements of Electromagnetics, M. N. Sadiku, Oxford University Press.
4. Foundations of Electromagnetic Theory, John R Reitz, Frederick J Milford and Robert W Christy, 1992, Addison Wesley.
5. Electromagnetics, B B Laud, New Age International Publishers.
6. Classical Electromagnetic Radiation, Mark A. Heald and Jerry B. Marion, Academic Press.
7. Optics, Ajoy Ghatak, McGraw-Hill.

**Course Type: MINOR**

**Course Name: Basics Electronics**

**Course Code: BSCPHSMN501**

Course Type: <b>MNC-5</b>	Course Details: <b>Basics Electronics</b>		L-T-P: <b>3-0-4</b>
		CA Marks	ESE Marks

Credit: <b>5</b>	Full Marks: <b>100</b>	Practical	Theoretical	Practical	Theoretical
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

**Course Learning Outcomes:**

*The course will enable the students to acquire necessary knowledge on semiconductor elements. With the knowledge of basic electronics, a student will understand the basic principles of the electrical or electronic circuits encountered in our daily life. They will acquire necessary hands-on experience on some widely used electronic circuits.*

**Course Content:**

1. **Semiconductor Diodes:** Conductor, insulator, and semiconductor on the basis of energy band. Intrinsic and extrinsic semiconductors, n-type, and p-type semiconductors. P-N junction, Barrier potential. Characteristics of P-N junction diode.

Junction breakdown, Zener diode and its characteristics, Tunnel diode, negative resistance (concepts and characteristics only). **[10 Hours]**

2. **Transistors:** NPN and PNP transistors, operation of a transistor, characteristics, current amplification factors, transistor characteristics for CE mode, DC load line. **[5 Hours]**

3. **Semiconductor devices:**

Diode based devices: Rectifiers, half wave and full wave rectifier, Zener diode as a voltage regulator. Amplifiers: Voltage and power gain of an amplifier, Transistor action as an amplifier, classifications of amplifier according to frequency range, and method of coupling (operations using only graphical method).

Feedback in amplifiers, positive and negative feedback (characteristics and effects only), concept of oscillator.

Operational amplifiers: OPAMP and its characteristics, why it is called operational amplifier, virtual ground, CMRR, Applications: Inverting Amplifier, Non-inverting amplifier.

**[15 Hours]**

4. **Boolean algebra and digital Electronics:** Number systems, decimal, binary, octal and hexadecimal systems. interconversion of binary to decimal, direct conversion of binary to octal (and hexadecimal) and octal (and hexadecimal) to binary.

Boolean Algebra, De Morgan's theorem, Basic and universal logic gates, half adder, half subtractor, 2x1 multiplexer, and demultiplexer. **[15 Hours]**

**Experiments on Basic Electronics ( Minimum 5 experiments are to be performed):**

1. To convert a given ammeter into a voltmeter and a given voltmeter to an ammeter for specific range. To find internal resistance of each and compare.

2. To draw the static characteristics curve of a semiconductor diode, and hence calculate the static and dynamic resistance in the linear portion of the characteristics.
3. To draw the dynamic characteristics curves of a PN junction diode in forward bias for three different loads. [During external exam only two should be drawn].
4. To draw the characteristics of a Zener diode and find the breakdown voltage, and dynamic resistance at nonlinear and linear portion.
5. To draw the load regulation curve of a Zener diode, and calculate the percentage regulation.
6. To draw the input and output characteristics of a NPN transistor in CE mode, and
  - (i). Identification of active, and saturation region.
  - (ii). Calculation of dc current gains from these graphs.
7. To find the close loop gain of an OPAMP in
  - (i). Inverting Amplifier
  - (ii). Non-inverting Amplifier configuration
8. To verify transistor as a NOT gate in CE configuration.
9. To verify NAND gate as an universal gate using NAND gate ICs.

## Semester – VI

**Course Type: MAJOR**

**Course Name: Nuclear and Particle Physics**

**Course Code: BSCPHSMJ601**

<b>Course Type:</b> <b>MJC-10</b>	<b>Course Details:</b> <b>Nuclear and Particle Physics</b>			<b>L-T-P:</b> <b>4-1-0</b>	
<b>Credit - 5</b>	<b>Full Marks:</b> <b>100</b>	<b>CA Marks</b>		<b>ESE Marks</b>	
		<b>Practical</b>	<b>Theoretical</b>	<b>Practical</b>	<b>Theoretical</b>
		.....	<b>30</b>	.....	<b>70</b>

**Course Learning Outcomes:**

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

1. *Explain structure and properties of nuclei, the mechanism of different radioactive decays and*

*their applications in peaceful use of nuclear energy.*

2. *Understand what are the elementary particles that constitute this known universe.*
3. *Gather capability of elementary problem solving in nuclear and particle physics.*

### **Course Content:**

#### **Theory**

<b>Module</b>	<b>Contents</b>	<b>Lecture. (Hrs.)</b>
<b>General properties of Nuclei</b>	Concept of atomic nucleus, constituents of nucleus, quantitative facts about mass, size, shape and density, binding energy, main features of average binding energy per nucleon vs mass number curve, N-Z plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.	<b>[10L]</b>
<b>Nuclear Models</b>	Liquid drop model approach, semi-empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energy.  Fermi gas model [ qualitative idea only]. Evidence of nuclear shell structure, basic assumption of shell model, magic number.	<b>[8L]</b>
<b>Radioactivity</b>	Law of radioactive decay, activity and its units, half-life and mean life, radioactive series, successive disintegration. radioactive dating.  Alpha decay: basics of $\alpha$ -decay process, Geiger-Nuttal law, theory of $\alpha$ -emission (qualitative idea).  Beta decay: energy kinematics of $\beta$ -decay, positron emission, electron capture, Pauli's neutrino hypothesis, neutrino detection.  Gamma decay: $\gamma$ -ray emission and kinematics, $\gamma$ -ray interaction during its passage through matter, internal conversion.	<b>[12L]</b>
<b>Nuclear Reactions</b>	Types of reactions, Conservation laws, kinematics of nuclear reactions, Q-value, reaction cross-section, concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	<b>[6L]</b>
<b>Particle Accelerators</b>	Van-de-Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Betatron, Synchrotrons, Accelerator facility available in India.	<b>[8L]</b>

<b>Nuclear Reactor Physics</b>	Discovery of neutron, sources and properties of neutron, nuclear fission, general characteristics, simple explanation from liquid drop model, energy release, general idea of reactors, thermalization of neutrons, nuclear fusion, and energy release in stars.	<b>[8L]</b>
<b>Particle Physics</b>	Fundamental forces, types of particles, symmetries, and conservation laws: energy and momentum, angular momentum, parity, baryon number, lepton number, isospin, strangeness and charm, quark model, properties of quark (u,d,s only), colour quantum number and gluons.	<b>[8L]</b>

**Reference Books :**

1. Introductory Nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd.,2008).
2. Concepts of Nuclear Physics, Bernard L Cohen (Tata Mcgraw Hill, 1998).
3. Basic ideas and concepts in Nuclear Physics – An introductory approach by K Heyde (IOP – Institute of Physics Publishing, 2004).
4. Introduction to the physics of nuclei and particles, R A Dunlap (Thomson Asia, 2004).
5. Introduction to high energy physics, D H Perkins, Cambridge Univ. Press.
6. Introduction to elementary particles, D Griffith, John Wiley & Sons.
7. Theoretical Nuclear Physics, J M Blatt and V F Weisskoph, Dover Pub. Inc., 1991.
8. Nuclear Physics, S N Ghosal, S Chand & Company Pvt Ltd.
9. Nuclear Physics, D C Tayal, Himalaya Publishing House.
10. Nuclear Physics, S B Patel, New Age International Publishers.

**Course Type: MAJOR**

**Course Name: Digital Electronics**

**Course Code: BSCPHSMJ602**

Course Type: <b>MJC-11</b>	Course Details: <b>Digital Electronics</b>		L-T-P: <b>3-0-4</b>		
Credit: <b>5</b>	Full Marks: <b>100</b>	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		<b>30</b>	<b>15</b>	<b>20</b>	<b>35</b>

### **Course Learning Outcomes:**

*The course will enable the students to acquire necessary knowledge on semiconductor elements. With the knowledge of basic electronics, a student will understand the basic principles of the electrical or electronic circuits encountered in our daily life. They will acquire necessary hands-on experience on some widely used electronic circuits.*

### **Course Content**

**Number System and Codes:** Decimal, Binary, Hexadecimal and Octal Number Systems, Base Conversions. Arithmetic Operations: Addition, Subtraction by Complement Method, Representation of Signed and Unsigned Numbers. Elementary idea of codes and their necessity, BCD.

[10 Hours]

**Logic Gates and Boolean Algebra:** Basic Postulates and Fundamental Theorems of Boolean Algebra, Switching Equivalent Circuits of Basic Gates, Truth Tables and Symbolic representation of OR, AND, NOT, NAND, NOR, XOR, XNOR Gates, Universal Logic Gates, Circuit Representation using basic and Universal Logic Gates.

[10 Hours]

**Combinational Logic Analysis:** Standard Representation of Logic Functions (SOP and POS), Karnaugh Map Minimization (up to four variables), Multiplexers and Demultiplexers and their NAND-NAND realization, Encoder and Decoder. Half & Full Adder and Subtractor, Comparator.

[10 Hours]

**Sequential Logic:** Latches, and Flip Flops: S-R, J-K, race around condition and Master Slave JK flip flop, D, and T flip flop. Counters up to 3 bit counting using flipflops (synchronous and asynchronous), Basic idea of Registers.

[8 Hours]

**Memory (Qualitative study):** Memory Technology, Types of Memory, Volatile and Non- Volatile, ROM, RAM, Concept of Primary, Secondary and Cache Memory.

[7 Hours]

### **Experiments on Digital Electronics (Minimum 5 experiments are to be performed)**

1. To verify transistor as a NOT gate in CE configuration.
2. To verify AND, OR, NOT, NAND, NOR gates using digital ICs.
3. To verify NAND gate as universal gate.
4. To design XOR gate using minimum number of NAND gates only.
5. To verify the De Morgan's law using various digital ICs.
6. To verify the logic identities using
  - (i). Basic logic gates
  - (ii). Universal logic gates

7. Realization of Boolean expression of an
  - (i). XNOR gate using basic logic gates and study it as an equality detector
  - (ii). XOR gate using basic logic gates and study it as an inequality detector
8. To design a half adder using XOR and AND gate ICs.
9. To design a half subtractor using XOR, NOT and AND gate ICs.
10. To design a full adder using XOR, AND and OR gate ICs.
11. To study (i) SR (ii). JK, (iii). D and (iv) T flip flop (Verification of truth table)
12. To design a 2 to 4 line decoder using basic logic gates

**Course Type: MAJOR**

**Course Name: Thermodynamics and Statistical Mechanics**

**Course Code: BSCPHSMJ603**

<b>Course Type:</b> MJC-12	<b>Course Details: Thermodynamics and Statistical Mechanics</b>			<b>L-T-P: 4-1-0</b>	
<b>Credit: 5</b>	<b>Full Marks:</b> <b>100</b>	<b>CA Marks</b>		<b>ESE Marks</b>	
		<b>Practical</b>	<b>Theoretical</b>	<b>Practical</b>	<b>Theoretical</b>
		<b>--</b>	<b>30</b>	<b>--</b>	<b>70</b>

**Course Objective: -**

This course aims to provide a comprehensive understanding of the fundamental principles of thermodynamics and statistical mechanics, enabling learners to analyze the behavior of matter and energy at both macroscopic and microscopic levels, and to apply these principles to diverse physical systems.

**Course Outcomes:**

- Explain the fundamental laws of thermodynamics and their applications in physical systems.
- Analyze heat engines, entropy changes, and phase transitions using thermodynamic potentials.

- Understand the statistical basis of entropy and relate microscopic configurations to macroscopic thermodynamic properties.
- Derive and apply the Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distribution laws to analyze the behavior of ideal gases and other systems.
- Connect the principles of statistical mechanics with Thermodynamics to explain macroscopic phenomena.

*Course Content:*

Theory Module	Contents	Class Reqd. (Hrs)
<b>Zeroth and First Law of Thermodynamics</b>	Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics, Concept of Temperature, Concept of Work & Heat, Thermodynamic state-space, exact and inexact differentials, State Functions, Quasi-static processes, First Law of Thermodynamics, Concept of Internal Energy, Work Done in various thermodynamic processes, Heat Capacities, Relation between $C_P$ and $C_V$ , Compressibility and Expansion Coefficients.	<b>(8L)</b>
<b>Second Law of Thermodynamics</b>	Limitation of First Law, Reversible and irreversible processes, Heat Engine and Heat Reservoir, The second law of thermodynamics: Clausius' and Kelvin-Planck Statements and their equivalence, Carnot engine and Carnot's theorems, Carnot cycle with an ideal gas, Thermodynamics Scale of Temperature, Clausius theorem, Concept of Entropy, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third Law of Thermodynamics, Unattainability of Absolute Zero.	<b>(12L)</b>
<b>Thermodynamic Potentials and Phase Transition</b>	Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Usage of Legendre transform, Derivation of Maxwell's thermodynamic relations, Joule-Thompson Effect, Concept of Phase and Phase Diagram, Triple point and critical point, Gibbs phase rule, First and second order phase transition, Clausius- Clapeyron Equation.	<b>(10L)</b>
<b>Microcanonical Ensemble</b>	Macrostate and Microstate, Phase space, Liouville's theorem, Boltzmann H-theorem, Concept of Ensemble, Fundamental postulates of statistical mechanics, Micro canonical ensembles, Entropy and Thermodynamic Probability, Evaluation of thermodynamic parameters using microcanonical ensemble, Classical Ideal Gas, Gibbs Paradox and its resolution, Sackur Tetrode equation, Law of Equipartition of Energy.	<b>(12L)</b>
<b>Classical and Quantum Statistics</b>	Non-interacting identical particles, Distinguishability and indistinguishability, Maxwell-Boltzmann Distribution Law with micro-canonical ensemble, Bosons and Fermions, Symmetric, and Antisymmetric wave functions, Bose-Einstein Distribution Law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose-Einstein condensation, Radiation as a photon gas, thermodynamic functions of photon gas, Bose derivation of Planck's law, phonon, Einstein and Debye theory of specific heat, Fermi-Dirac Distribution Law, Thermodynamic functions of strongly Degenerate fermi gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals due to electrons.	<b>(18L)</b>

**Books Recommended:**

1. *Heat and Thermodynamics* - M.W. Zemansky, Richard Dittman,
2. *Thermodynamics, Kinetic Theory & Statistical Thermodynamics* - Francis W. Sears and Gerhard L. Salinger,
3. *Statistical Mechanics* - R.K. Pathria
4. *Fundamentals of Statistical and Thermal Physics* - F. Reif,
5. *A treatise on Heat* - M. N. Saha and B.N. Srivastava
6. *Concepts in Thermal Physics* - S.J. Blundell and K.M. Blundell
7. *An introduction to thermal physics* - D. Schroeder

**Course Type: MAJOR****Course Name: Atomic, Molecular and Condensed Matter Physics****Course Code: BSCPHSMJ604**

Course Type: MJC13	Course Details: <b>Atomic, Molecular and Condensed Matter Physics</b>			L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	<b>30</b>	.....	<b>70</b>

**Course Objectives:**

1. To understand the basic concepts of atomic spectra.
2. To have a clear knowledge about rotational, vibrational and electronic spectra.
3. To understand about fundamentals of crystal structure.
4. To analyze the crystal structure using X-ray diffraction methods.
5. To acquire knowledge on the basics of magnetic phenomena on materials and various types of magnetization.
6. To learn the properties of superconducting materials.

**Course Learning Outcomes:**

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

1. Explain atomic spectra.
2. Explain rotational, vibrational and electronic spectra of molecules.

3. Understand different lattice types and explain the crystal diffraction.
4. Explain the concept of energy bands and be able to differentiate between metals, insulator and semiconductors.
5. Describe the magnetic properties of solids.
6. Explain superconductivity and important parameters related to it.

<b><u>Atomic and Molecular and Condensed Physics</u></b>		
<b>Topic</b>	<b>Contents</b>	<b>Lectures (Hrs)</b>
<b>Atomic Spectra-</b>	Quantization of atomic energy levels, Good quantum numbers and selection rules. Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical idea. Bohr-Sommerfield model. Fine structure. Study of fine structure by Michelson-Morley experiment.	10
<b>Vector atom model</b>	Magnetic moment of the electron, Lande g factor. Vector model, space quantization. Zeeman effect (normal and anomalous). Explanation from vector atom model.	06
<b>Many electron model:</b>	Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state.	06
<b>Molecular spectroscopy</b>	Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only).	08
<b>Crystal structure of solids</b>	Amorphous and Crystalline Materials, Lattice Translation Vectors, Lattice with a Basis, Unit Cell, Types of Lattices, Miller Indices. Sodium chloride structure, Zinc Blende structure, Diamond structure, Reciprocal lattice, Brillouin Zones. Diffraction of X-rays by Crystals, Bragg's Law. Atomic and Geometrical Factor.	10
<b>Magnetic properties of matter</b>	Dia-, Para-, and Ferromagnetic Materials. Classical Langevin Theory of dia- and Paramagnetic materials, Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.	8

<b>Electronic properties of materials</b>	Free electron theory of metals, The Drude model of electrical conduction, derivation of Ohm's law, The Wiedemann-Franz law, Hall effect. Superconductivity: General properties, Meissner effect, critical temperature and critical field.	8
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**References/Suggested readings:**

1. Atomic Physics (Modern Physics) by Ghoshal S. N.
2. Concepts of Modern Physics by Arthur Beiser and Shobhit Mahajan.
3. Introduction to Atomic Spectra by Harvey Elliott White
4. Atomic & Molecular Spectra: Laser by Raj Kumar
5. Elements of Spectroscopy Atomic, Molecular and Laser Physics' by Gupta
6. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
7. Elements of Solid State Physics, J. P. Srivastava, 4 th Edition, 2015, Prentice-Hall of India.
8. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
9. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
10. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
11. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
12. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
13. Solid state Physics by Puri & Babbar
14. Modern Physics by A. Beiser

## *Internship Guideline*

<b>Programme: B.Sc.</b>	<b>Year: III</b>	<b>Semester: VI</b>			
<b>Discipline: Physics</b>					
<b>Course Name: Summer Internship</b>					
<b>Course Code: SI601</b>					
Course Type: <b>SI (Practical)</b>	Course Details: <b>SIMC-1</b>	L-T-P: <b>0 - 0 – 4</b>			
Course Credit: <b>2</b>	Full Marks: <b>50</b>	CA Marks	ESE Marks		
		Practical	Theoretical	Practical	Theoretical
		<b>30</b>	---	<b>20</b>	---
<b>Course Overview:</b>					
<p>Internship in <b>Physics</b> is gaining wide attention and importance in course curriculum as it promises to provide first-hand experience to the students, along with conventional class room teaching. It enables students in comprehending the way of working in an organization, leading to improvement of the skill/ aptitude needed to tackle real-world spatial challenges and building research capabilities with learning opportunities.</p>					
<b>Course Objectives:</b>					
<p>Following are the intended objectives of engaging undergraduate students with major course as <b>Physics</b> in internship for employability and research internship programs: (i) Integration of workshop with workplace; (ii) Understanding of the world of work; (iii) Physical and hybrid model learning; (iv) Developing research aptitude; (v) Exposure in emerging technologies; (vi) Enhance entrepreneurial capabilities; (vii) Development of decision- making and teamwork skills; (viii) Stimulate collaborative influence; and (x) Enhancing professional competency.</p>					
<b>Learning Outcome:</b>					
<p>✧ Students shall get an excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience during the internship provides much more professional experience, often worth more than classroom teaching.</p> <p>✧ The students will learn various soft skills such as time management, positive attitude and communication skills while performing the tasks assigned in the internship organization.</p>					
<b>Professional Skill Development:</b>					
<p>✧ The obtained knowledge is vital to test the theoretical learning in practical situations by accomplishing the tasks assigned during the internship.</p> <p>✧ This knowledge will help to develop essential soft skills like time management, organization, adaptability, problem-solving, and teamwork.</p>					
<b>Internship Categories (students can opt any one)</b>			<b>60 hrs</b>		

## I. Conventional

In **conventional/traditional** internships, interns may work on specific projects or tasks in an **organization** (IIT, NIT, IIIT, IISER, IISC, IACS, Engineering colleges etc.), **research institutes (CSIR-CMERI, TIFR etc.) / science laboratory (CGCRI, NPL etc.)/parent university (KNU)/other Universities** and R&D institutions. These academic/research institutes will be referred as External Entities in our subsequent sections.

After completion of the course, the respective mentor will issue a completion certificate along with his/her opinion about the merit of the course.

## II. Field-based Learning

Interns may undertake a **field-based learning** in collaboration with local industry, government and private organizations to enhance employability. Interns will be provided opportunities to actively engage in on-site learning and hands-on training to work on research tools, techniques, methodologies, equipment and other aspects for enhancing employability.

### Role of Internship Supervisor

An internship supervisor is any individual of the host Department/Institute who will be nominated by the Institution/Department for monitoring, supervising, and evaluating the student during the internship duration.

- Internship Supervisor will be selected at the start of the academic year for each batch.
- The Internship Supervisor from the host institute/department should monitor the regularity of the intern at his/her workplace. Students should preferably inform the Internship Supervisor at least one day before availing leave during the internship except for emergencies.

### Role of Mentor

A mentor is an individual professional of any External Entity (mentioned above) who is identified by the HEI or by students himself/herself through their network. The mentor should be identified and his/her concurrence should be conveyed to the internship supervisor. He/she will be providing professional/research guidance to the student during the internship. The mentors will also facilitate networking with other subject matter experts/professionals, which will enhance the internship experience and learning of the intern.

They shall be making the timely evaluation of a student and provide him completion certification/report for submission in HEI.

- The mentor needs to guide the students digitally or physically throughout the internship duration.

- The mentor needs to check and validate the performance of students fortnightly and after the completion of the internship, issue the certificate/report.
- The mentor must ensure the learning of competencies with research orientation among the students during the internship duration.

### Summary Guidelines:

- **Title:** Internship Assessment through Projects (Group Internship is allowed)
- **Duration:** 60 hours (may be undertaken at any time during the 2<sup>nd</sup>/ 4<sup>th</sup>/ 6<sup>th</sup> Semester)
- **Nature of Internship Project:** Inter-Institutional Activities/ Activities with Industrial/ Research Organizations/ Soft-skill/ Technological Skill providing Institutes/ Science Laboratory
- After the completion of the Internship Programme, the student will submit a report with relevant photographs as part of the report include an **Attendance Document** and an **Authenticated Certificate** jointly signed by the **Supervisor/ Mentor**.
- A **mentor** will be identified for **Conventional Internship/ Field-based Learning** by the mother department or by students himself/ herself through their network. The mentor should be identified, and his/ her concurrence should be conveyed to the internship supervisor. He/ she will be providing professional/ research guidance to the student during the internship. The mentors will also facilitate networking with other subject matter experts/ professionals, which will enhance the internship experience and learning of the intern.
- Students can opt for activities from the list of Internships for enhancing the employability and/ or developing the research aptitude.

### Course Evaluation:

- ✧ Short term project work will be performed by students in any universities/research institutes/research centre/industry (Except his/her own college).
- ✧ Concerned Department of the College will approach the External Entities (mentioned above) for seeking the permission to pursue the project work.
- ✧ Students may also approach to the External Entities for carrying out their internship. However, the students should get approval from the mother department before commencing the project work.
- ✧ There will be one internal member (supervisor) from college department who will liaise with the mentor for monitoring the project work.
- ✧ After completion of project work, he/she will deliver a power point presentation in his/her own college for the assessment of his/her project work.

✧ Finally, the completion certificate will be signed by the supervisor and the mentor.

- **Continuous Assessment: 30 Marks**

1. Evaluation of Report: There shall be an evaluation of the report by the Internship Mentor and Supervisor. [Mentor : **20 Marks**, Supervisor: **10 Marks**]

- **End Semester Examination: 20 Marks**

At the end of the semester, a viva-voce will be conducted by the department and one External Examiner/ Expert appointed by the University (concerned UGBOS) to assess the report and knowledge acquired by the students.

**Marks Pattern:** Format of presentation and the quality of the intern's report: 10; Viva voce: 10.

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