**National Curriculum and Credit Framework (NCCF)**

Syllabus For

**B. Sc (Honours)/ B. Sc (Honours with Research) 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

<table>
<tr><td>Course Type: Major<br>(Theory and Practical)</td><td colspan="3">Course Details: MJC -1</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

***Course Learning Outcomes:***

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

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

## Course Content:
## MJC-1: Mechanics & General Properties of Matter
## 45 Hrs

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

10L

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

6L

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

8L

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

2L

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

5L

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

7L

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

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

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

7L

***References/ Suggested Readings:***


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


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

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

1. To study the Motion of Spring and calculate (a) Spring constant, (b) Acceleration due to gravity.
2. To determine the Moment of Inertia of a Flywheel / regular-shaped body.
3. To determine Coefficient of Viscosity of water by Capillary Flow (Poiseuille‟s) Method.
4. Determination of Young‟s modulus by method of flexure.
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the elastic Constants of a wire by Searle‟s method.
7. To determine the value of acceleration due to gravity using Bar Pendulum.
8. To determine the value of acceleration due to gravity using Kater’s Pendulum.
9. Determination of surface tension of a liquid by Jaeger‟s method.

10. Determination of surface tension of a liquid by capillary-rise method.
11. Determination of the rigidity modulus of a wire by statical /dynamical method

***Reference Books for Laboratory Experiments:***


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

# MINOR COURSE

## Course Name: Mechanics and General properties of Matter Course Code: BSCPHSMN101

<table>
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***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.*
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## Course Content:

## MNC-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.

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

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

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

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

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2. *Classical Mechanics – J. C. Upadhyay, (Himalaya Publ.).*
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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*

**Experiments to be performed in the first semester** (At least 6 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.
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10. Determination of surface tension of a liquid by capillary-rise method.

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

***Reference Books for Laboratory Experiments:***


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

# MD COURSE

# COURSE NAME: PHYSICAL SCIENCE

# COURSE CODE: MDC101

<table>
<tr><td>Course Type: MD (Theory)</td><td colspan="3">Course Details: MDC-1</td><td colspan="2">L-T-P: 3-0-0</td></tr>
<tr><td rowspan="3">Credit: 3</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td></td><td>15</td><td></td><td>35</td></tr>
</table>

**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

<table>
<tr><td>Course Type: SEC-1<br>(Practical)</td><td colspan="3">Course Details: SEC-1</td><td colspan="2">L-T-P: 0-0-6</td></tr>
<tr><td rowspan="3">Credit: 3</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>30</td><td></td><td>20</td><td></td></tr>
</table>

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

**Sample Programming (suggested at least eight):**

1. (a) Conversion of components of a vector among cartesian, polar and cylindrical coordinate systems.

   (b) Conversion of list of temperatures from celsius to fahrenheit scale.

   (c) Calculating the positions, velocities of a particle from given mass, acceleration. (d) Finding the real / complex roots of a quadratic equation using Sridharacharya method.

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

***References/ Suggested Readings:***

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

# SEMESTER-II:

## MAJOR COURSE

## Course Name: Electricity and Magnetism Course Code: BSCPHSMJ201

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

***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 equtions 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, Cou-lomb'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. Pois-son'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, Electro-static 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, Sus-ceptibility, 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 mag-netic 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 electromag-netic 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 have to be performed):

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown low resistance using Potentiometer.

3. To determine an unknown low resistance using Carey Foster's Bridge.
4. To compare capacitances using De' Sauty's bridge.
5. To determine self-inductance of a coil by Anderson's bridge.
6. Measurement of magnetic field strength B and its variation in a solenoid (determinination of dB/dx).
7. To verify the Thevenin and Norton theorems in a wheatstone bridge.
8. To verify the superposition, and maximum power transfer theorems in a wheatstone bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its
    (a) anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine temperature co-efficient of resistance of a metal / semiconductor by a meter-bridge.

## MINOR COURSE

## Course Name: Electricity and Magnetism Course Code: BSCPHSMN201

<table>
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***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 equtions 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

## MNC-2: Electricity and Magnetism

## 45 Hours

**Electric Field for a point charge :** Concept of charge, Conservation and quantization of charge, Cou-lomb'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.

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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, Sus-ceptibility, 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 mag-netic 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 electromag-netic 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 have to be performed):

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown low resistance using Potentiometer.
3. To determine an unknown low resistance using Carey Foster's Bridge.
4. To compare capacitances using De' Sauty's bridge.
5. To determine self-inductance of a coil by Anderson's bridge.
6. Measurement of magnetic field strength B and its variation in a solenoid (determinination of dB/dx).

7. To verify the Thevenin and Norton theorems in a Wheatstone bridge.
8. To verify the superposition, and maximum power transfer theorems in a Wheatstone bridge.
9. To study response curve of a Series LCR circuit and determine its: -
   (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine temperature co-efficient of resistance of a metal / semiconductor by a meter-bridge.

## Skill Enhancement Course

(Anyone from the two listed below will be provided )

## Course name: Electrical Circuits and Network Skill

## Course Code: BSCPHSSE201

<table>
<tr><td>Course Type: SEC (Practical)</td><td colspan="3">Course Details: SEC-2</td><td colspan="2">L-T-P: 0-0-6</td></tr>
<tr><td rowspan="3">Credit: 3</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td></td><td>20</td><td></td></tr>
</table>

## Course Content

## SEC-2: Electrical Circuits and Network Skill

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

**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.

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

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

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

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

**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).

**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 connection in domestic purposes.
6. Pin identification of a 741 IC and design an inverting amplifier.
7. Using multimeter determine the values of resistance, capacitor, inductor and construct a series LCR circuit with a known frequency ac voltage source. Draw the phrasor diagram by determining the voltages across each component.
8. Using multimeter determine the values of resistance, capacitor, inductor and construct a parallel LCR circuit with a known frequency ac voltage source. Draw the phrasor diagram by determining the voltages across each component.
9. Fabrication of tank circuit and study of signal generation of particular frequency.

***References/ Suggested Readings:***


1. *A textbook in Electrical Technology - B L Theraja - S Chand & Co.*
2. *A textbook 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

<table>
<tr><td>Course Type: SEC (Practical)</td><td colspan="2">Course Details: SEC-2</td><td colspan="2">L-T-P: 0-0-6</td></tr>
<tr><td rowspan="3">Credit: 3</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td></td><td>20</td><td></td></tr>
</table>

## Course Content

## SEC-2: Basic Instrumentation Skills

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

**Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and re-sistance. specifications of a multimeter and their significance.

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

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

**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, elec-trostatic 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 oscillo-scope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

**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.

**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.

**Digital Instruments:** Principle and working of digital meters. Comparison of analog & digital instru-ments. 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 reso-lution.

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

# SEMESTER-III

## Major Course

## Course Name: Mathematical Methods in Physics I
## Course Code: BSCPHSMJ301

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

***Course Learning Outcomes:***

*After the completion of course, the students will have 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

**Calculus:** Infinite sequences and series; Conditional and Absolute Convergence; Tests for Convergence (proofs not required), Functions of several real variables - partial differentiation, Constrained Maximization using Lagrange Multipliers

10L

**Statistics:** Random variables - joint and conditional probabilities,; Moments - mean, variance, skewness and curtosis, Examples of continuous probability distribution functions (Binomial, Gaussian, and Poisson). Citation of simple examples from Physics.

10L

**Determinant and Matrices:** Basic idea of matrix algebra, Rank of a matrix; Solution of simultaneous equation of matrices by Cramer's rule; Solution of systems of linear homogenous and inhomogeneous equations by matrix method; Cayley-Hamilton theorem; Characteristics equation for a square matrix and diagonalization; Properties of Eigenvalues and eigenvectors of matrices; Symmetric, Skew- symmetric, Hermitian, Orthogonal and Unitary matrices and their properties.

10L

**Ordinary Differential Equations:** Classifications of singularities for a Second Order Ordinary Differential Equation (ODE) - Fuchs' theorem; Series Solution of second order ODE with variable coefficients by Frobenius-Fuchs" method; Solutions of Legendre, Bessel and Hermite ODE. about x=0.

10L

**Partial Differential Equations**: Partial Differential Equations in Physics; Types – elliptical, hyperbolic and parabolic (examples from Physics), Solutions by separation of variables method; Basic examples- Laplace's equation, Diffusion equation, Wave equation. Solution of Laplace's equation in Cartesian, spherical polar (spherically symmetric cases), and cylindrical polar (cylindrically symmetric problems) coordinate systems.

10L

**Special Functions:** Properties of Legendre Polynomials: Rodrigues Formula, Generating Function. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality.

10L

**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

05L

**Fourier Series and Transform:**

**a)** Periodic functions in Physics, Dirichlet Conditions (Statement only). Wronskian of two functions - linear independence and completeness, orthogonality; Fourier series expansion of periodic functions in terms of sine and cosine as basis, Calculation of Fourier coefficients in some simple cases, Complex representation of Fourier series. Expansion of non-periodic functions, Even and odd functions as special cases. Applications in Physics – vibration of string.

**b)** Introduction of Fourier transform as Fourier series of infinite period, propeties of Fourier transform, Inverse Fourier transform, Parseval Identity. Dirac delta function and its important properties.

10L

***References/ Suggested Readings***


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

***References/ Suggested Readings***


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

# MAJOR Course

## Course Name: OPTICS

## Course code: BSCPHSMJ302

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

***Course Objective:-***

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

***Course Learning Outcomes:***

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

- *Understand Interference as superposition of waves from coherent sources derived from same parent source.*
- *Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.*
- *In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc.*

## *Course Content:*

## Theory

**Introduction to Geometrical Optics:** Concept of ray, ray optics limit, geometrical and optical path, Fermat's Principle, Principle of least path and extremum paths-example of extremum path. Aplanatic surface, Application to laws of reflection and refraction for a) plane surface and b) spherical surface. Application to determine lens formulae.

4L

**Matrix Method:** Translation, refraction and reflection matrix. System matrix for thick and thin lenses. Cardinal points of optical system. Application to image formation by combination of two lenses. Concept of objective and eyepiece, Huygens Eyepiece and Ramsden Eyepiece as examples of lens combination, merits and demerits.

8L

**Aberration:** Seidal aberration and its different types. Its removal, Abbes Sine condition. Aplanatism and Aplanatic Surface. Its application to high power microscope objective. Chromatic aberration – longitudinal and transverse. Achromatism- achromatic doublet and separated doublet.

4L

**Wave Motion:** Plane Progressive elastic waves, Spherical and Cylindrical Waves; Longitudinal and Transverse Waves, Differential Equation for progressive wave (1d and 3d) and harmonic solutions, Relations among dilatation, condensation and excess pressure, Derivations of wave velocity of a longitudinal wave through an elastic medium and transverse wave through a string, Phase and Group velocity, Energy Transport associated with a Longitudinal Wave, Intensity of Wave.
Definition and properties of wave front, Huygens Principle.

8L

**Interference of light waves:** Definition and properties of wave front, Huygens Principle, Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring. Michelson's interferometer, Multiple beam interference – reflected and transmitted pattern. Fabry-Perot interferometer.

7L

**Diffraction of light waves:** Fresnel and Fraunhofer class, Fresnel's half period zones; explanation of rectilinear propagation of light; zone plate. Fraunhofer diffraction due to a single slit, double slit and circular aperture (qualitative). Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating.

7L

**Polarisation:** Different states of polarisation; double refraction, Malus law, Huygen's construction for uniaxial crystals; polaroids and their uses. Lissajous Figures: Production and analysis of plane, circularly and elliptically polarised light by retardation plates and Babinet compensator; Rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter

7L

***References/ Suggested Readings*:**


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

7. *Introduction To Optics- A.K. Ghatak*

8. *Optics- Hetch And Zajack.*

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

***WEB REFERENCES:***

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

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

**Optics Lab [At least five experiments to be done]**

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

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

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

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

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

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

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

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

9. Determination of separation of D1 and D2 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

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

***Course Objective: -***

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

***Course Learning Outcomes:***

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

- *Understand Interference as superposition of waves from coherent sources derived from same parent source.*
- *Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from aperture, understand Fraunhoffer and Fresnel Diffraction.*
- *In the laboratory course, student will gain hands-on experience of using various optical instruments.*

## *Course Content:*
## Theory

**Introduction to Geometrical Optics:** Concept of ray, ray optics limit, geometrical and optical path, Fermat's Principle, Principle of least path and extremum paths-example of extremum path. Aplanatic surface, Application to laws of reflection and refraction for a) plane surface and b) spherical surface. Application to determine lens formulae.

5L

**Waves:** Plane Progressive elastic waves, Longitudinal and Transverse Waves, Differential Equation for 1d progressive wave and its solutions, Relations among dilatation, condensation and excess pressure, Derivations of wave velocity of a longitudinal wave through an elastic medium and transverse wave through a string, Phase and Group velocity, Energy Transport associated with a Longitudinal Wave, Intensity of Wave.

8L

**Interference:** Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference in thin film; fringes of equal inclination and equal thickness; Newton's ring.

10L

**Diffraction:** Fresnel and Fraunhofer diffraction, Fraunhofer diffraction due to a single slit, double slit. Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism.

8L

**Polarisation:** Transverse nature of light waves. Different states of polarization; double refraction, retardation plates, Malus law, polaroids and their uses. polarizer and analyzer, Production and analysis of plane, circularly and elliptically polarized light, Rotatory polarisation and optical activity; Fresnel's explanation of optical activity; Biquartz and half shade polarimeter.

7L

**Laser, LED, and Optical Fiber:** Spontaneous and stimulated emissions, Population inversion, theory of lasing action (Laser). Basic principle of LED, Characteristics and applications. Basic principle of optical fiber, Characteristics and applications. Numerical aperture

7L

***References/ Suggested Readings:***


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


***WEB REFERENCES:***


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

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


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

1. To determine the focal length of a concave lens by combination method.
2. To determine the focal length of a concave lens by auxiliary method.

3. Determination of the refractive index of a liquid by using a plane mirror and a convex lens.
4. Determination of the refractive index of a water by using traveling microscope.
5. Determination of angle of prism and to determine refractive index of the material of a prism using sodium source.

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

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

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

9. Determination of grating element of a diffraction grating using a semiconductor laser / sodium source.

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

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

# SEMESTER-III
## MD Course
## Course Name: Indian Astronomy
Course code: **MDC-303**

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

***Course Objective: -***

***Course Learning Outcomes:***

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

## *Course Content:*
## Theory

**Introduction to Indian Astronomy: -**

**Historical Background**:

**Vedic Period**

**Rigveda**: Reference to celestial bodies and their movements.

**Yajurveda and Atharvaveda**: References to the Sun, Moon, and stars.

**Vedanga Jyotisha**: Early systematic approach to astronomy, focusing on the calendar and timekeeping.

**Classical Period**

**Aryabhata**: His heliocentric model, calculation of the Earth's circumference, and the concept of the Earth's rotation.

**Varahamihira**: Contributions to meteorology, astrology, and his encyclopedic work, Brihat Samhita.

**Medieval Period**:

**Bhaskara II**: His work on calculus, accurate prediction of eclipses, and the Siddhanta Shiromani.

7L

## Basic Concepts and Terminology: -

**Astronomical Units**:

**Yojana**: Detailed explanation of its use in ancient texts and its approximate modern equivalent.
**Nakshatra**: The 27 lunar mansions, their names, and significance in astrology and astronomy.

**Kala, Kashta, and Nimesha**: Definitions and their use in timekeeping.

3L

## Indian Astronomical Texts: -

**Siddhāntas**:

**Surya Siddhanta**: Detailed contents, including planetary motion, eclipses, and timekeeping methods.
**Aryabhatiya**: Aryabhata's contributions to mathematics and astronomy, such as his calculation of the value of pi and the concept of the Earth's rotation.

**Brahmasphuta siddhanta**: Brahmagupta's work on algebra, his methods for solving quadratic equations, and his contributions to astronomy.

6L

## Calendars and Time keeping: -

**Lunisolar Calendar**:

**Structure**: Detailed explanation of the combination of lunar months and solar years in the Indian calendar.
**Significance**: Importance of the lunisolar calendar in religious and agricultural activities.
**Time Measurement**: **Tithi**: Definition and use of a lunar day in the calendar.

**Nakshatra**: Description of the lunar mansions and their role in timekeeping. **Yoga**: Explanation of the combination of the Sun and Moon's positions and its significance.

6L

## Modern Indian Astronomy: -

**Institutions**: Contributions of institutions like the Indian Institute of Astrophysics and the Inter-University Centre for Astronomy and Astrophysics, NCRA, GMRT, Radio Astronomy Center ,TIFR, ISRO etc
**Key Researchers**: Notable modern Indian astronomers and their work; Meghnad Saha, Subhrmanyam Chandrasekhar, Nikhil Ranjan Sen, A. K. Roychowdhury, J. V. Narlikar.

**ISRO's Space Missions**: Overview of missions like Chandrayaan, Mangalyaan, and their impact on astronomy.

8L

***References/ Suggested Readings*:**


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

# SEMESTER-IV
## MAJOR COURSE
## Course Name: Classical Mechanics and Special Theory of Relativity
## Course Code: BSCPHSMJ401

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

***Course Learning Outcomes:***

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

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

## *Course Content:*
## Theory

**Central force Motion:** Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram, Determination of orbits from central force and determination of central force from orbits.

10L

**Constrained Motion:** Constraints – Definition and classification with examples. Forces of constraint. Degrees of Freedom. Generalized coordinates. Virtual displacement and Principle of Virtual work. D'Alembert's principle and its applications in simple cases.

5L

**Lagrangian Formulation:** Lagrange's equation of motion from D'Alembert's principle and its application to simple cases. Comparison of Newtonian & Lagrangian formulations. Newton's equation of motion from Lagrange's equations. Generalized momenta and energy. Cyclic coordinates and its applications. Properties of kinetic energy function T, Ordinary potential energy function, Euler Lagrange equation of motion for conservative system.

10L

**Hamiltonian Formulation:** Hamilton's equations from Legendre's dual transformation to the Lagrangian

of a system. Determination of Hamiltonian from Lagrangian for simple cases. Properties of the Hamiltonian and Hamilton's equations of motion. Application to simple systems.
Configuration space, Phase space and State space. Homogeneity of time and conservation of energy; Homogeneity of space and conservation of linear momentum, Isotropy of space and conservation of angular momentum.

10L

**Calculus of Variation:** Variational principle, Euler Lagrange equation of motion from variational principle, shortest distance between two points, Brachistochrone, Geodesic, Minimum surface of revolution.
Hamilton's principle and its significance. Lagrange's equation and Hamilton's equations from Hamilton's principle.

10L

**Canonical Transformations:** Canonical transformations; Generating functions; examples of canonical transformations; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations.

10L

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

5L

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

10L

***References/ Suggested Readings***


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

# SEMESTER-IV
## Course Name: Heat and Thermal Physics
## Course Code: BSCPHSMJ402

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

***Course Outcomes:***

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

### *Course Content:*

### Theory (45 Lectures)

**Kinetic Theory of Gases:**

**Growth of Kinetic Theory:** Basic assumptions of kinetic theory,Pressure ex-erted by ideal gas using concepts of spherical polar coordinates and solid angle, Deduction of perfect gas laws, concepts of temperature, rms speed, Avogardo's Hypothesis, Boltzman Constant.

**Maxwell's velocity distribution law:** Maxwell's assumptions, derivation of the law, root mean square and most probable speeds. Experimental confirmation of the distribution law: Zartman and Ko method, Simpson and Ster's method, Richardson experiment. Reduced form of Max-well's distribution, Energy distribution and momentum distribution, Dependence of the distribution on temperature and pressure of the gas.

**Effect of finite size of molecules:** Collision probability, Mean free path, Distribution of free paths, derivation of mean free path using the concept of collision cross section, Clausius mean free path, correction by Maxwell (no derivation, only corrected expression). Experimental determination of mean free path by Born.

9L

**Equation of state for Real Gases:**

**Equipartition of energy:** Degrees of freedom, mono, di and tri-atomic mole-cules, Equipartition of energy, Derivation using the concepts of Maxwell's energy distribution and taking energy as homogeneous function of position and momentum coordinates, applications of equipartition of energy to specific heat of gas and derivation of Doulong Petit's law.

**Transport phenomena:** Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Interrelation between these coefficients and mean free path.

**Experimental evidence of molecular motion:** Brownian motion, Special features, Distribution of pressure in a vertical column of gas in equilibrium under gravity and derivation of particle distribution, modification due to modification of mass of Brownian particle due to Buoyancy, Concept of determination of Avogadro's number using Brownian motion.

**Experimental Background:** Insufficiency of ideal gas equation, Amagat's experiment, Virial equation of state and Boyle temperature, Andrews' experiment and concept of critical temperature, state of matter near critical point, van der-Waals equation of state.

**Discussion on van der Wall's equation:** Roots of van der Wall's equations, isotherms from van der wall's equation, Critical Constants, Reduced equation of state and law of corresponding state, critical coefficient, critical coefficient of a gas, law of corresponding states; Virial Coefficients, Boyle temperature. **Other equations of state:** Defects of van der Wall's equation, Clausius equation, Dieterici's equation and Barthelot's equation (no derivation of any of these equations is required).

8L

### Conduction of Heat:

Difference between conduction and other processes of heat transfer, dependence of rate of heat conduction on structure and property of the medium and idea of thermal conductivity. 1L

**One dimensional heat flow:** Mathematical theory of heat conduction and Fourier's equation for one dimensional heat flow, thermal and thermometric conductivity, solution for of Fourier's equation for rectilinear flow of heat, Ingen Hausz's experiment, freezing of pond and heat conduction through composite slab, Periodic flow of heat, conductivity of earth's crust.

**Three-dimensional heat flow:** spherical and cylindrical flow of heat, Wide-man- Franz law (statement and discussion).

10L

### Radiation:

**Source of thermal radiation:** Material radiation and energy radiation examples, similarities of thermal radiation and light, Blackbody, Spectral emissive and absorptive powers, total emission from an elementary area, Kirchoff's law, Ritche's experiment, properties of blackbody radiation, Total energy of radiation, Stefan-Boltzmann law, Newton's law of cooling, Determination of Stephan's constant by hemispherical blackbody and thermocouple.

**Energy distribution in the blackbody:** Wien's law, Rayleigh-Jeans formula, ultraviolet catastrophe, Planck's law, and deduction of Wien's law, Rayleigh Jeans law and Stephan's constant from Planck's law, Temperature of the Sun from Plank's law and Wien's law.

**Radiation pyrometer:** Basic principle based on Stephan's law.

10L

***Books Recommended:***

*1. P K Chakraborty, Thermal Physics, Sreedhar Publications*

*2. Roy and Gupta, Thermal Physics, Books and Allied.*

*3. Garg, Bansal, and Ghosh, Thermal Physics, 2nd Ed, Mac Graw Hill.*

***Reference Books:***

*1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, McGraw-Hill.*

*2. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, Indian Press*

*3. Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. Narosa.*

*4. Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, S. Chand publications.*

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

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

## SEMESTER-IV
## Course type: MINOR Course
## Course Name: Fundamentals of Thermal Physics
## Course Code: BSCPHSMN401

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

*Course 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

**Kinetic Theory of Gases:**

**Growth of Kinetic Theory:** Basic assumptions of kinetic theory, Pressure exerted by ideal gas using concepts of spherical polar coordinates and solid angle, Deduction of perfect gas laws, concepts of temperature, rms speed, Avogardo's Hypothesis, Boltzman Constant.

**Maxwell's velocity distribution law:** Maxwell's assumptions, derivation of the law, root mean square and most probable speeds. Experimental confirmation of the distribution law: Zartman and Ko method,

**Effect of finite size of molecules:** Collision probability, Mean free path, Distribution of free paths, derivation of mean free path using the concept of collision cross section, Clausius mean free path, correction by Maxwell (no derivation, only corrected expression).

**Real gas :** Deviation from ideal behavior. Vander Waal's equation of state, critical constant from P-V isotherms

8L

### Conduction of Heat:

**Equipartition of energy:** Degrees of freedom, mono, di and tri-atomic molecules, Equipartition of energy (no derivation), applications of equipartition of energy to specific heat of gas and derivation of Doulong-Petit's law.

**Transport phenomena:** Viscosity, Conductivity and Diffusion, General method of viscosity and conductivity from kinetic theory, Diffusion, Discussion on Inter-relation between these coefficients and mean free path.

**Experimental evidence of molecular motion:** Brownian motion, Special features, Distribution of pressure in a vertical column of gas in equilibrium under gravity and derivation of particle distribution, Concept of determination of Avogadro's number using Brownian motion.

**One dimensional heat flow:** Mathematical theory of heat conduction and Fourier's equation for one dimensional heat flow, thermal and thermometric conductivity, solution for of Fourier's equation for rectilinear flow of heat, Ingen Hausz's experiment, Periodic flow of heat, conductivity of earth's crust (no derivation)

**Three-dimensional heat flow:** spherical and cylindrical flow of heat, Wideman-Franz law (statement and discussion).

6L

**Radiation:**

**Source of thermal radiation:** Material radiation and energy radiation examples, similarities of thermal radiation and light, Blackbody, Spectral emissive and absorptive powers, total emission from an elementary area, Kirchoff's law, properties of blackbody radiation, Total energy of radiation, Stefan-Boltzmann law, Newton's law of cooling.

**Energy distribution in the blackbody:** Wien's law, Rayleigh-Jeans formula, ultraviolet catastrophe, Planck's law.

**Radiation pyrometer:** Basic principle based on Stephan's law.

7L

**Thermodynamics:** Laws of Thermodynamics: Thermodynamic Description of system, Zero$^{th}$ Law of thermodynamics and temperature. First law and internal energy, con-version of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between $C_P$ & $C_V$, Work Done during Isothermal and Adiabatic Processes, Compressibility &Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Un attainability of absolute zero.

10L

**Statistical Mechanics:** Phase space, Macrostate and Microstate, Entropy and Thermodynamic prob-ability, Boltman entropy relation, Maxwell-Boltzmann distribution from en-tropy maximization.

Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Ein-stein distribution law - photon gas - comparison of three statistics (Derivation not required) Qualitative discussion on Fermi Level, B-E Condensation.

8L

***Books Recommended**:*


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

*4. Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, 1st Edn., 2008, S. Chand.*

**Heat and Thermal Physics - Lab [Marks: 50]**

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
4. To determine the Temperature Coefficient of Resistance of platinum by Platinum Resistance Thermometer
5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
6. To determine temperature coefficient of resistance by meter-bridge.
7. Determination of coefficient of linear expansion by optical lever.
8. Determination of coefficient of linear expansion by Pullinger's apparatus
9. Determination of pressure coefficient of air by Jolly's apparatus.
10. To determine the Coefficient of Thermal Conductivity of Cu by Searle"s Apparatus.
11. To study the variation of Thermo-emf of a Thermocouple with Difference 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: **SEC(Practical)** | Course Details: **SEC-3** | | L-T-P: **0-0-6** | |
|---|---|---|---|---|
| Credit: **3** | Full Marks: **50** | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | 30 | ……. | 20 | …… |

***Course Learning Outcomes:***

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

- *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-Pivortal condensation, Gauss Seidal method. Electrical Circuit analysis using Kirchhoff's law

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

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

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

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

***References/ Suggested Readings:***


1. *Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.*
2. *Schaum"s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.*
3. *Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)*
4. *Computer Oriented Numerical analysis by V. Rajaraman.*
5. *A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning*
6. *Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn. , 2007, Wiley India.*
7. *Numerical Methods by S.A. Molla.*
8. *Computation Physics: Problem Solving with Python, 3rd Edition by Rubin H. Landau, Manuel J Páez, Cristian C. Bordeianu.*
9. *Computational Physics by N.H.Giordano and H. Nakanishi, Person.*


# SKILL ENHANCEMENT COURSE

## (Evaluation is to be done internally)
## Course Name: Scientific writing and Documentation
## Course Code: BSCPHSSE402

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

***Course Learning Outcomes:***

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

- *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: **MJC-7** | Course Details: **Analog Electronics** | | | L-T-P: **3-0-4** | |
|---|---|---|---|---|---|
| Credit: **5** | Full Marks: **100** | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | **30** | **15** | **20** | **35** |

***Course Learning Outcomes:***

*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 Diffu-sion, 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 re-sponse of a CE amplifier. Comparative study of CB, CC and CE configurations. Class A, B & C Amplifiers. Class-B Push-pull amplifier.

[8L]

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

[2L]

6. **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]

7. **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. Ap-plications 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]

8. **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

<table>
<tr><td>Course Type: MJC-8</td><td colspan="3">Course Details: Quantum Mechanics-I</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

***Course 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 )

**Failures of Classical:** 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).

3L

**Basics of new ideas:** (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.

5L

(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.

3L

**Theoretical formulation:** (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.

(b) Commutation relations- e.g.,. [x,p], [$L_i$, $L_j$] Compatible observables and simultaneous measurements, Ehrenfest theorem.

12L

**Applications of Quantum Mechanics (1D problems):**

a) Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle.

(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.

12L

**Applications of Quantum Mechanics (3D problems):**

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

(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).

10L

***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: **MJC-9** | Course Details: **Electromagnetic Theory & its Applications** | | | L-T-P: 4**-1-0** | |
|---|---|---|---|---|---|
| Credit: **5** | Full Marks: **100** | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | **--** | **30** | **--** | **70** |

***Course Learning Outcomes:***

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

1. *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 he 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

<table>
<tr><td>Course Type: MNC-5</td><td colspan="3">Course Details: Basics Electronics</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>15</td><td>20</td><td>35</td></tr>
</table>

***Course 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:***

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

Junction breakdown, Zener diode and its characteristics, Tunnel diode, negative resistance (concepts and characteristics only).

10L

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

5 L

**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.

15L

**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. 15L

**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

<table>
<tr><td>Course Type:<br><br>MJC-10</td><td colspan="3">Course Details:<br><br>Nuclear and Particle Physics</td><td colspan="2">L-T-P:<br><br>4-1-0</td></tr>
<tr><td rowspan="3">Credit - 5</td><td rowspan="3">Full Marks:<br><br>100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>30</td><td>……</td><td>70</td></tr>
</table>

***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

**General properties of Nuclei:** 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.

10L

**Nuclear Models:** 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.

8L

**Radioactivity**: Law of radioactive decay, activity and its units, half-life and mean life, radioactive series, successive disintegration. radioactive dating.
Alpha decay: basics of α-decay process, Geiger-Nuttal law, theory of α-emission (qualitative idea).
Beta decay: energy kinematics of β-decay, positron emission, electron capture, Pauli's neutrino hypothesis, neutrino detection
Gamma decay: γ-ray emission and kinematics, γ-ray interaction during its passage through matter, internal conversion.

12L

**Nuclear Reactions**: 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).

6L

**Particle Accelerators:** Van-de-Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Betatron, Synchrotrons, Accelerator facility available in India.

8L

**Nuclear Reactor Physics:** 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.

8L

**Particle Physics:** 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.

8L

***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: **MJC-11** | Course Details: **Digital Electronics** | | L-T-P: **3-0-4** | |
|---|---|---|---|---|
| Credit: **5** | Full Marks: **100** | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | **30** | **15** | **20** | **35** |

***Course Learning Outcomes:***

*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.
[10L]

**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. [10L]

**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.
[10L]

**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. [8L]

**Memory (Qualitative study):** Memory Technology, Types of Memory, Volatile and Non- Volatile, ROM, RAM, Concept of Primary, Secondary and Cache Memory. [7L]

**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 substractor 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

<table>
<tr><td>Course Type: MJC-12</td><td colspan="3">hermodynamics and Statistical Mechanics</td><td colspan="2">L-T-P: 4-1-0</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>--</td><td>30</td><td>--</td><td>70</td></tr>
</table>

***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:*

**Zeroth and First Law of Thermodynamics:** Extensive and intensive Thermodynamic Variables, Thermodynamic Equi-librium, Zeroth Law of Thermodynamics, Concept of Temperature, Concept of Work & Heat, Thermodynamic state-space, exact and inexact differen-tials, 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.

8L

**Second Law of Thermodynamics:** Limitation of First Law, Reversible and irreversible processes, Heat Engine and Heat Reservoir, The second law of thermodynamics: Clausius' and Kel-vin-Planck Statements and their equivalence, Carnot engine and Carnot's theorems, Carnot cycle with an ideal gas, Thermodynamics Scale of Tem-perature, Clausius theorem, Concept of Entropy, Entropy changes in reversi-ble & irreversible processes, Entropy-temperature diagrams, Third Law of Thermodynamics, Unattainability of Absolute Zero.

12L

**Thermodynamic Potentials and Phase Transition:** 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.

10L

**Microcanonical Ensemble:** Macrostate and Microstate, Phase space, Liouville's theorem, Boltzmann H-theorem, Concept of Ensemble, Fundamental postulates of statistical me-chanics, Micro canonical ensembles, Entropy and Thermodynamic Proba-bility, Evaluation of thermodynamic parameters using microcanonical en-semble, Classical Ideal Gas, Gibbs Paradox and its resolution, Sackur Tet-rode equation, Law of Equipartition of Energy.

12L

***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

<table>
<tr><td rowspan="1">Course Type: MJC13</td><td colspan="2">Course Details: Atomic, Molecular and Condensed Matter Physics</td><td colspan="2">L-T-P: 4-1-0</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>30</td><td>……</td><td>70</td></tr>
</table>

***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 magnetizations.*
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.*

## Contents

**Atomic Spectra**-: 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 10L

**Vector atom model:** Magnetic moment of the electron, Lande g factor. Vector model, space quantization. Zeeman effect (normal and anomalous). Explanation from vector atom model. 6L

**Many electrons model:** Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state.

6L

**Molecular spectroscopy:** Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only).

8L

**Crystal structure of solids:** 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.

10L

**Magnetic properties of matter:** 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.

8L

**Electronic properties of materials:** 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.

8L

***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*

<table>
<tr><td colspan="3">Programme: B.Sc.</td><td colspan="2">Year: III</td><td colspan="2">Semester: VI</td></tr>
<tr><td colspan="7">Discipline: Physics</td></tr>
<tr><td colspan="7">Course Name: Summer Internship</td></tr>
<tr><td colspan="7">Course Code: SI601</td></tr>
<tr><td>Course Type: SI (Practical)</td><td colspan="3">Course Details: SIMC-1</td><td colspan="3">L-T-P: 0 - 0 – 4</td></tr>
<tr><td rowspan="3">Course Credit: 2</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>---</td><td>20</td><td>---</td></tr>
</table>

**Course Overview**:

Internship in **Physics** is gaining wide attention and importance in course curriculum as it promises to provide first-hand experience to the students, along with conventional classroom 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.

**Course Objectives**:

Following are the intended objectives of engaging undergraduate students with major course as **Physics** 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.

**Learning Outcome**:

- 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.
- 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.

**Professional Skill Development**:

- The obtained knowledge is vital to test the theoretical learning in practical situations by accomplishing the tasks assigned during the internship.
- This knowledge will help to develop essential soft skills like time management, organization, adaptability, problem-solving, and teamwork.

| | | |
|---|---|---|
| | Internship Categories (students can opt any one) | 60 hrs |

**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 Insti-tution/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 2nd/ 4th/ 6th 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 rele-vant 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 iden-tified, 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/re-search centre/industry (Except his/her own college).

✧ Concerned Department of the College will approach the External Entities (mentioned above) for seek-ing 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 men-tor 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.

✧ Finaly, 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 Ex-aminer/ 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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# SEMESTER-VII

## Statistical Mechanics II

## Course Code: BSCPHSMJ701

| Course Name | Course Type | Course Code | L - T - P | Course Credit | CA Marks | | ESE Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Statistical Mechanics-II | MAJOR | BSCPHSMJ701 | 4 - 1 - 0 | 5 | 00 | 30 | 00 | 70 | 100 |

***Course Objective: -***

- *This course builds on the foundations of statistical mechanics by introducing canonical and grand canonical ensembles, methods for treating interacting and quantum systems, and the theoretical framework for phase transitions and critical phenomena.*
- *It equips students to analyze thermodynamic behaviour, fluctuations, and collective effects in a wide range of physical systems.*
- *It also gives light on the effects of interaction in statistical systems.*

**Course Content:**
**Theory (60 Lectures)**

1. **Foundational concepts**
   Phase space distributions; time vs ensemble averages; ergodicity, Review of ensemble theory. Coarse-graining, irreversibility,
   Review of micro-canonical ensemble, Boltzmann and Gibb's entropy relation, Liouville's theorem, Limitations of microcanonical ensemble.
   **(5 L)**
2. **Canonical Ensemble and Grand Canonical Ensemble**
   Canonical ensemble: partition function, free energy, entropy, internal energy, heat capacities; energy fluctuations.

Grand canonical ensemble: chemical potential and thermodynamic interpretation; grand partition function; grand potential and thermodynamic relations; fluctuations in particle number and internal energy.
Thermodynamic limit and equivalence of ensembles; fluctuation–response relations. Applications: two-level system, classical harmonic oscillator, ideal classical gas.

**(12L)**

3. **Classical Real Gas**
Corrections to Ideal Gas, Virial expansion for real gases, Cluster expansion (qualitative treatment), mean-field theories (van der Waals, Curie-Weiss);

**(6L)**

4. **Quantum Statistical Mechanics**
Density Operator, Density Matrix formalism, von Neumann entropy, Density matrices for microcanonical, canonical and grand-canonical ensembles, Simple examples of density matrix - one electron in a magnetic field, particle in a box, quantum harmonic oscillator, Density matrix for beam of spin ½ particles, construction of density matrix for different spin states and calculation of the polarization vector.

**(10L)**

5. **Ideal Quantum Gas**
Grand canonical treatment of ideal quantum gases, density of states, thermodynamic functions. statistics of occupation numbers; pressure of a quantum ideal gas.
Ideal Bose gas: equation of state, Bose–Einstein condensation, critical temperature, condensate fraction, thermodynamic properties near BEC transition.
Ideal Fermi gas: equation of state; Fermi integrals; pressure, internal energy, entropy, statistical properties. Low-temperature behaviour of degenerate Fermi systems, Specific heat of Bose and Fermi gases.

**(12L)**

6. **Phase transition and critical phenomena**
Concept of phase transitions, classification of phase transitions, Order parameter and spontaneous symmetry breaking, with examples (ferromagnets, liquid–gas transition, Bose–Einstein condensate, superconductivity).
Critical phenomena: critical exponents, scaling relations, universality; correlation functions and correlation length; Ginzburg criterion.
Basic idea of spin-exchange between 2 electrons (Heitler-London), Ferro and Antiferro-magnetic exchange.
Ising model – exact solution in one dimension, Calculation of critical exponents (alpha, beta, gamma and delta) using mean field theory (Weiss) and Landau theory.

**(15L)**

***Course Outcomes:***

- *Apply canonical and grand canonical ensembles to determine thermodynamic properties and fluctuations.*
- *Analyze interacting classical gases using virial expansion and mean-field approximations.*
- *Use density matrices to describe quantum ensembles and compute properties of simple quantum systems.*
- *Evaluate ideal Bose and Fermi gases and interpret phenomena like BEC, superfluidity, and Fermi degeneracy.*
- *Explain phase transitions and critical behaviour using order parameters, critical exponents, and simple models*
- *Cluster expansion technique can be useful to initiate research work on the theoretical ad-vancement in the field of quantum Monte Carlo simulations.*

***Books Recommended**:*


1. *Statistical Mechanics - R.K. Pathria*
2. *Fundamentals of Statistical and Thermal Physics - F. Reif,*
3. *An introduction to thermal physics - D. Schroeder*
4. *Statistical Mechanics -K. Huang*
5. *Statistical Mechanics: An Elementary Outline – Avijit Lahiri*
6. *Statistical mechanics - B. K. Agarwal and M. Eisner*

# SEMESTER-VII

## MAJOR COURSE

## Quantum Mechanics- II

## Course Code: BSCPHSMJ702

| Course Name | Course Type | Course Code | L - T - P | Course Credit | CA Marks | | ESE Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Quantum Mechanics-II | MAJOR | BSCPHSMJ702 | 4 - 1 - 0 | 5 | 00 | 30 | 00 | 70 | 100 |

***Course Objectives: -***

*The course aims to develop a fundamental understanding of the principles and mathematical formalism of quantum mechanics, including wave functions, operators, angular momentum, and approximation methods. It also introduces students to the application of quantum mechanics in describing atomic systems and solving physically relevant problems.*

***Course Outcomes: -***

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

- *Explain the fundamental postulates of quantum mechanics and apply the operator formalism to analyse quantum states, observables, and measurements.*
- *Solve selected quantum mechanical problems involving one dimensional potentials, the harmonic oscillator, and the hydrogen atom, and interpret their physical significance.*
- *Analyse orbital and spin angular momentum, including their algebra, eigenstates, and coupling in atomic systems.*
- *Apply different formulations of quantum dynamics (Schrödinger, Heisenberg, and Interaction pictures) to describe the time evolution of quantum systems.*
- *Use perturbation theory, variational methods, and other approximation techniques to obtain approximate solutions for quantum systems where exact solutions are not feasible.*

**Unit I: Foundations of Quantum Mechanics and Exactly Solvable Systems**

**State Function and Operator Formalism**

Physical interpretation of the wave function and probability density. State vectors and wave functions; Dirac bra–ket notation (introductory use only). Operators corresponding to physical observables, eigenvalue equations, expectation values, and measurement postulates. Superposition principle and expansion of a state function. Commutation relations, compatible and incompatible observables, uncertainty relations. Change of representation and continuous basis (position representation).

**(8 L)**

**One-Dimensional Quantum Systems (Selected Topics)**
Quantum motion in one-dimensional potentials with emphasis on **Dirac delta function potentials**: bound states and scattering states, penetration and tunneling through delta potentials.

**(8 L)**

**Linear Harmonic Oscillator**
Linear harmonic oscillator solved **exclusively using the operator (ladder operator) method**. Creation and annihilation operators, energy spectrum and eigenstates. Expectation values.
**Coherent states** and their properties.

**(6 L)**

**Central Potential and Hydrogen Atom**
Motion of a particle in a spherically symmetric potential. Hydrogen atom: qualitative solution and physical interpretation of eigenfunctions. Emphasis on the structure and meaning of
$\psi_{nlm}(r, \theta, \phi)$ and discrete energy levels $E_n$. No detailed derivations; discussion limited to providing conceptual groundwork for angular momentum and spin.

**(8 L)**

**Unit II: Angular Momentum and Spin**

**Orbital Angular Momentum**
Angular momentum operators and their commutation relations. Eigenvalues and eigenfunctions of
$L^2$ and $L_z$. Spherical harmonics and their physical significance. Degeneracy of energy levels and quantum numbers $l$ and $m$.

**(8 L)**

**Spin Angular Momentum**
Intrinsic spin of particles. Spin operators and spin commutation relations. Spin-½ systems, Pauli spin matrices, spin eigenstates, and measurement of spin components. Addition of angular momentum (qualitative introduction).

**(5 L)**

**Total Angular Momentum and Applications**
Coupling of orbital and spin angular momentum. Physical relevance in atomic systems.

**(3 L)**

**Unit III: Equation of Motion:**

Heisenberg, Schroedinger and Interaction pictures.

**(2 L)**

**Unit IV: Approximation methods:**

Time-independent perturbation theory for non-degenerate and degenerate states. Applications: Anharmonic oscillator, Helium atom, Stark effect in hydrogen atom, Variational methods. Time-dependent perturbation theory; Harmonic perturbation; Fermi's golden rule. Sudden approximation. Examples and problems.

**(12 L)**

**References for *Advanced Quantum Mechanics- I*:**

1) 'Quantum Physics' by Robert Eisberg and Robert Resnick (John Wiley and sons).
2) 'Introduction to Quantum Mechanics', D, J. Griffiths.
3) 'Quantum Mechanics: Concepts and Applications", N. Zettili.
4) Quantum Mechanics, B. H. Bransden and C. J. Joachain
5) 'Quantum Mechanics' by L. I. Schiff (McGraw-Hill Book, New York).
6) 'Quantum Mechanics' by C. Cohen-Tannoudji.

7) 'Principles of Quantum Mechanics' by R. Shankar

# SEMESTER-VII

## Condensed Matter Physics-II

## Course Code: BSCPHSMJ703

| Course Name | Course Type | Course Code | L - T - P | Course Credit | CA Marks | | ESE Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Condensed Matter Physics-II | MAJOR | BSCPHSMJ701 | 4 - 1 - 0 | 5 | 00 | 30 | 00 | 70 | 100 |

***Course Objectives***

*In this advanced course on condensed matter physics students will be introduced to structures and properties of solids. They will learn about various kinds of bondings in crystalline solids, lattice vibrations and lattice specific heat. Then they will be introduced to free electron theory of metals as well as band theory of solids arising due to motion of electrons through periodic potentials. They will also learn about advanced topics like superconductivity, Josephson junctions, liquid crystals and quasi-crystals.*

***Course Outcomes***

*Upon successfull completion of the course students will have knowledge about:*

- *Bonding in solids*
- *Lattice vibrations, phonons and lattice specific heat*
- *Drude theory of metals, Fermi energy and electronic properties like conductivity and thermoelectric power*
- *Bloch's theorem, band theory of solids and classification of metals, insulators and semi-conductors*
- *Superconductivity – zero resistance, Meissner effects, thermodynamics and electrodynamics in superconductors and distinction between type-I and type-II superconductors, Josephson junction.*
- *Defects dislocations, translational vs orientational orders, liquid crystals and quasi-crystals.*

## Course Content

Different types of Crystal binding-ionic, covalent, metallic and weak-bonding, cohesive energy.

**(5 L)**

Vibration of lattice, normal modes, spring-mass coupled system, mono and di-atomic chains, periodic lattices, phonons, force constant from experiments, quantization of elastic waves. Lattice specific heat.

**(10 L)**

Free electron theory of metals, Fermi-Dirac distribution, Free electrons, boundary conditions, Density of levels in 1, 2 & 3 dimensions, Fermi momentum and Fermi energy, Connection between electron density and Fermi energy. Specific heat of metals, thermoelectric power.

**(10 L)**

Band theory, periodic potential, Bloch's theorem, tight binding approximation, Brillouin zones (first and second) for square, cubic lattices, Energy bands in reduced zone scheme, energy bands and Fermi surfaces in a few metals as example. Metals, insulators and semiconductors.

**(15 L)**

Properties of Superconductor, O ccurrence of Superconductivity, Superconducting Elements, Zero Resistance, Meissner Effect, AC Resistance, Entropy, Specific Heat. Type-I and Type-II Superconductors, London's Theory, Thermodynamics of Superconductor, BCS Theory, Cooper pair.

**(10L)**

Josephson junctions ; superfluidity. Defects and dislocations. Ordered phases of matter : traslational and orientational order, kinds of liquid crystalline order. Quasi crystals.

**(10L)**

***Books Recommended:***

1. *Ashcroft & Mermin, Solid State Physics;*
2. *C. Kittel, Introduction to Solid State Physics;*
3. *Marder, Condensed Matter Physics.*
4. *Quantum Transport : From atoms to Transistors, SupriyoDatta.*
5. *Elementary Solid State Physics, M. Ali Omar, Pearson*

# SEMESTER-VII

## MAJOR COURSE

## Mathematical Methods in Physics-II

## Course Code: BSCPHSMJ704

| Course Name | Course Type | Course Code | L - T - P | Course Credit | CA Marks | | ESE Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Mathematical Methods in Physics-II | MAJOR | BSCPHS MJ704 | 4 - 1 - 0 | 5 | 00 | 30 | 00 | 70 | 100 |

***Objective:***

- *Students in all branches of physics need to be familiar with several mathematical techniques to understand content of their studies.*
- *The main motivation of this course is to develop a mathematical basis such that it can strengthen the ability of students to understand the mathematical treatment of physical problems which are encountered in the entire course.*

***Course outcome:***

- *Students are expected to be well acquainted with technique to solve different problems related to complex analysis, differential equations, integral transform, linear algebra.*
- *Students would be capable to apply their knowledge to read/understand other branches of physics, especially in Quantum Mechanics, Electrodynamics, Solid State Physics, Quantum Optics.*
- *The understanding of Group Theory will be useful in studying various symmetry properties in high energy physics, quantum mechanics as well as condensed matter physics.*

## Contents

**Functions of a complex variable:** Analytic functions, Cauchy-Riemann equations, integration in the Complex plane, Cauchy's theorem, Cauchy's integral formula. Liouville's theorem. Morera's theorem. Proof of Taylor and Laurent expansions. Singular Points and their classification. Branch Point and branch Cut. Riemann sheets. Residue theorem. Application of residue theorem to the evaluation of definite integrals and the summation of infinite series.

**(10 L)**

**Linear vector spaces:** Vector spaces, subspaces, bases and dimension, Linear independence and orthogonality of vectors, Gram-Schmidt orthogonalisation procedure. Linear operators. Matrix representation. The algebra of matrices. Special matrices. Rank of a matrix. Elementary transformations. Elementary matrices. Equivalent matrices. Solution of linear equations. Linear transformations. Change of Basis. Eigenvalues and eigenvectors of matrices. The Cayley-Hamilton theorem. Diagonalisation of matrices.

**(10 L)**

**Integral transforms:** Fourier and inverse Fourier transforms. Convolution theorem. Parseval Relation, Solution of ordinary and partial differential equations by Fourier transform.
Laplace and inverse Laplace transforms, Convolution theorem. Solution of ordinary and partial differential equations.

(**10 L**)

**Green's functions:** Green's function and its properties. Solution of inhomogeneous differential equations using Green's function. Laplace wave equation and heat equation in two (2) & three (3) Dimension.

**(10 L)**

**Fundamentals of Tensor:** Metric or Fundamental Tensor**,** Covariant, Contravariant, and Mixed Covariant and Contravariant Components of a Vector; Relation Between gij, $g^{st}$, and $\delta^{s}w$, Inner Product, Coordinate Transformation of the Fundamental Tensor.
Tensor calculus; Base Vector Differentials in the General Case, Tensor Differentiation, Product Rule for Covariant Derivatives, Gradient, Divergence, and Curl of a Vector Field.

**(10 L)**

**Group theory:** Definition. Group postulates. Finite and infinite groups, order of a group, subgroup; rearrangement theorem, multiplication table. Cosets, Lagrange's theorem, Invariant subgroups, Isomorphism and homomorphism. Cyclic and other distinct groups. Permutation and alternating groups. Cayley's theorem. Finite group, continuous group: SO (3) and SU (2).
Group Representations, Faithful and unfaithful representations. Invariant subspaces and reducible representations. Reducible and irreducible representations.

**(10 L)**

***Books Recommended:***

1. *M. R. Spiegel (Schaum's outline series), Theory and Problems of Complex Variables, McGraw-Hill Publishing Co. (June 1974)*
2. *G. Arfken, Mathematical Methods for Physicists, Academic Press (2012)*
3. *P. Dennery and A. Krzywicki, Mathematics for Physicists, Dover Publications (2012)*
4. *Mary L. Boas; Mathematical Methods in the Physical Sciences, Wiley (2006)*
5. *W. Joshi, Matrices and Tensors, NEW AGE (1995)*

6. *M. Hammermesh, Group Theory and Its Application to Physical Problems, Dover Publications (1989)*
7. *M. Tinkham, Group Theory and Quantum Mechanics, Dover Publications Inc. ( 2003)*
8. *A. W. Joshi, Group Theory, New Age International (1997)*
9. *F. A. Cotton, Chemical Application to Group Theory, Wiley (2008)*
10. *N. Deo, Graph Theory, Courier Dover Publications (2017)*
11. *Carl M. Bender, Steven A. Orszag, Advanced mathematical methods for scientists and engineers, Springer (2010)*
12. *Meinhard T. Schobeiri, Tensor Analysis for Engineers and Physicists: With Application to Continuum Mechanics, Turbulence, and Einstein's Special and General Theory of Relativity, Springer Nature (2022)*
13. *Spiegel, Murray R.: Schaum's Outline of Theory and Problems of Vector Analysis and an Introduction to Tensor Analysis. McGraw-Hill, New York, NY, 1959.*

# SEMESTER-VII

## MINOR COURSE

## Modern Physics I

## Course Code: BSCPHSMN701

| Course Name | Course Type | Course Code | L - T - P | Course Credit | CA Marks | | ESE Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Modern Physics-I | MINOR | BSCPHS MN701 | 3 - 0 - 4 | 5 | 30 | 15 | 20 | 35 | 100 |

***Objective:***

- *Learn how electromagnetic radiation and subatomic particles exhibit both wave and particle characteristics.*
- *Master the Photoelectric Effect and Compton scattering to comprehend how energy is exchanged in discrete packets (photons).*
- *Establish the baseline for how classical physics breaks down at sub-atomic levels, necessitating quantum theory.*
- *Trace the development of atomic models (Rutherford to Bohr) to understand how stability and spectral lines are explained by quantized electron orbits.*
- *Learn how to use wave functions to determine the probability distribution of finding a particle in a given space (the probabilistic wave-mechanical model).*
- *Study stimulated emission, population inversion, and optical pumping as mechanisms for generating highly coherent, monochromatic light.*

***Course Learning Outcomes:***

*The course will enable the students to acquire necessary knowledge on development of quantum phenomena. Upon successful completion of the course, they will be able to describe the wave particle duality, analyze the concept of matter waves and uncertainty principle and apply Schrödinger equation to non-relativistic particles. They will learn the physics behind laser and holography and their applications in real world.*

## Course Content

**Theory (45 Lectures)**

1. **Nature of radiation:** Blackbody radiation. Wien's displacement law, Raleigh-Jeans law, Planck's Quantum hypothesis, Planck's radiation law. Photoelectric effect and Compton effect. Wave particle duality. de Broglie wavelength and matter waves; Davisson-Germer experiment. Phase velocity and Group velocity. Heisenberg Uncertainty Principle. [10L]

2. **Atomic structure:** Rutherford's atomic model, Bohr's model of hydrogen atom, Spectral series of hydrogen. Wilson-Sommerfeld quantization rule. Bohr correspondence principle. Resonance, excitation and ionization potential. Measurement of resonant potential- Frank Hertz experiment. Limitations of Bohr model. [10L]

3. **Introduction to wave mechanics:** Wave function. Time dependent Schrödinger wave equation. Free particle wave equation and general wave equation. Physical interpretation of wave function: Probability density. Quantum measurements: Normalization of wave function. Orthogonality of wave functions. Stationary states. Conservation of probability density. Time independent Schrödinger wave equation. Dynamical variables as linear Hermitian operators. Eigen functions and Eigenvalues, The expectation values of position and momentum. [15L]

4. **Lasers:** Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three level and four level laser. Ruby Laser and He- Ne Laser. Basic lasing action. [7L]

5. **Holography:** Basic principles of holography. Features of hologram. Recording of a hologram. Reconstruction of image from hologram. Application of holography. [3L]

**Practical**

**List of experiments (Any five are to be performed)**

1. Determination of the Planck's constant using black body radiation and photo-detector.
2. Determination of the Planck's constant using LEDs of at least 4 different colors.
3. Study on Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
4. Determination of work function of material of filament of directly heated vacuum diode.
5. Determination of *e*/*m* of electrons by using bar magnet.
6. Determination of the wavelength of a laser/Na vapor lamp using diffraction of single slit.
7. Determination of the wavelength of a laser/ Na vapor lamp using diffraction of double slits.
8. Determination of wavelength of laser/ Na vapor lamp using plane diffraction grating.
9. Study on quantization of energy levels using Frank Hertz Experiment.

***References/ Suggested Readings:***


1. *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. R. Eisberg and R. Resnick, (Wiley)*
2. *Concept of Modern Physics by A. Beiser, (Mc Graw Hill)*
3. *Introduction to Modern Physics by H.S. Mani and G.K. Mehta (Affiliated East-West Press Pvt. Ltd.)*
4. *Atomic and Nuclear Physics by S.N. Ghosal (S. Chand & Co.)*
5. *Modern Physics by R. Murugeshan (S. Chand & Co.)*
6. *Introduction To Quantum Mechanics by S. N. Ghosal (Calcutta Book House)*
7. *Quantum Mechanics: Theory and Applications by A. K. Ghatak and S. Lokenathan (Macmillan, Delhi)*
8. *Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn, 2020, (Tata McGraw-Hill)*
9. *Modern Physics by A B Gupta (Books and Allied Pvt. Ltd.)*
10. *A Text book of Light by B Ghosh and K G Mazumdar (Sreedhar Publishers)*
11. *Lasers- Fundamentals and Applications by Ajoy Ghatak and K. Thyagarajan (Laxmi Publications)*
12. *Lasers And Non-Linear Optics by B B Laud (New Age International Private Limited)*

# SEMESTER – VIII

## MAJOR COURSE
## Computational Physics

## Course Code : BSCPHSMJ801

| Course Name | Course Type | Course Code | L-T-P | Course Credit | CA Marks | | ESE Marks | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Computational Physics | MAJOR | BSCPHSMJ801 | 3-0-4 | 5 | 30 | 15 | 20 | 35 | 100 |

***Course Objectives***

*In this course the students will be introduced to high level programming language like C. They will also be introduced to numerical methods like solution of polynomial and non-polynomial equations, numerical interpolation, numerical integration, ordinary differential equations. These are widely used in diverse areas of physics, materials science and allied fields. Introduction to finite element methods will help students to learn about various discretization methods and solution of partial differential equations on discrete space-time grid. The hands on numerical projects will introduce the students to code development.*

***Course Outcomes***

*Upon completion of this course the students will learn about*

- *High level programming language C.*
- *Real root finding for polynomial and non-polynomial/transcedental equations.*
- *Numerical interpolation of a given data set and integrate functions of single variable.*
- *Simple solution of ordinary differential equations.*
- *Finite difference methods and its implication for physics problems like Heat/Schrodinger equation, Laplace equation and boundary value problems,*

***Students will also learn about***

- *Algorithm to develop a computer program.*
- *Writing, debugging and executing a computer program and gain first hand knowledge in implementation of numerical scheme.*

## Course Content

**Elements of programming language :** Algorithms and flow charts ; Structures of a high level language program. Features of C language, constants and variables ; operators and expressions ; conditional statements and loop statements ; functions ; arrays ; pointers ; structures, unions and enumeration.

**[14L]**

**Elements of computational techniques :** Roots of functions and polynomial equations : Bi-section method and Newton-Raphson method ; multiple roots.

**[6 L]**

Interpolation and extrapolation : Lagrange and Newton interpolation ; divided difference method ; forward, backward and central difference.

**[6 L]**

Numerical integration : Trapezoidal and Simpson's rule ; Error estimation.

**[5 L]**

Differential equation : Solution of first order ordinary differential equation by Runge-Kutta method

**[6 L]**

Finite difference method : Discretization of full and partial derivatives ; parabolic PDE (Heat equation) ; Crank-Nicholson method ; elliptic PDE (Laplace equation) ; boundary condition ; hyperbolic PDE (Wave equation)

**[8 L]**

**Laboratory**
**(Any *five* need to be performed)**

To write and execute computer programs in C/C++/Fortran90/Python language for the following problems

1. Solution of equation using bi-section method.

2. Roots of a function using Newton-Raphson method.

3. Interpolation of a given set of data using forward/backward interpolation.

4. Estimate of definite integral using Trapezoial and Simposon's method.

5. Solution of first order ordinary differential equation by Runge-Kutta method.

6. Solution of Heat equation using Crank-Nicholson method.

7. Solution of boundary value problem of Laplace equation.

***Book References***


1. *Byron S Gottfried, Programming with C (2018), McGraw Hill*
2. *E. Balagurusamy, Programming in ANSI C (2019), McGraw Hill*
3. *V. Rajaraman, Computer Oriented Numerical Methods (1993), PHI*
4. *E. Balagurusamy, Numerical Methods (2017), Tata McGRAW Hill*
5. *F. Acton, Numerical Methods that Work (1997), Harper and Row*
6. *S. D. Conte and C. D. Boor, Elementary Numerical Analysis (2005), McGraw Hill*
7. *S. S. Shastry, Introductory Methods of Numerical Analysis (2012), PHI*

# SEMESTER – VIII

## MAJOR COURSE

## Relativistic Mechanics & Electrodynamics

## Course Code : BSCPHSMJ802

| Course Name | Course Type | Course Code | L-T-P | Course Credit | CA Marks | | ESE Marks | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Relativistic Mechanics & Electrodynamics | MAJOR | BSCPHSMJ802 | 4-1-0 | 5 | 0 | 30 | 0 | 70 | 100 |

***Course Objectives***

*This course introduces the relativistic formulation of classical electrodynamics, including Lorentz transformations, four-vector calculus, electromagnetic field tensors, radiation from charged particles, and electrodynamics in moving media. It forms the foundation for advanced studies in high-energy physics, plasma physics, astrophysics, and accelerator science.*

***Course Outcomes***

*Upon completion of this course the students will learn about :*

- *Understand the geometry of space-time and Lorentz invariance.*
- *Learn covariant formulation of Maxwell's equations.*
- *Study relativistic motion of charged particles in electromagnetic fields.*
- *Analyze radiation from accelerated charges using relativistic theory.*
- *Explore electrodynamics of moving media and introductory curved-space-time electrodynamics.*

**Module 1: Foundations of Special Relativity**

**(8 L)**

- Lorentz transformations
- Time dilation, length contraction, simultaneity
- Velocity addition
- Minkowski spacetime and spacetime intervals
- Four-vectors: position, velocity, momentum, force
- Energy-momentum relation
- Lorentz invariants

**Module 2: Relativistic Fields and Potentials (14 Lecture)**

- Review of Maxwell's equations
- Four-potential $A^{\mu}$ and gauge transformations
- Electromagnetic field tensor $F^{\mu\nu}$
- Lorentz transformation of **E** and **B**
- Covariant form of Maxwell's equations
- Charge-current four-vector $J^{\mu}$
- Electromagnetic invariants: $E^2 - c^2B^2$, $\mathbf{E}\cdot\mathbf{B}$
- Retarded time, retarded potentials
- Liénard–Wiechert potentials and fields

**Module 3: Motion of Charged Particles in Electromagnetic Fields**

**(10 L)**

- Lorentz force and relativistic equations of motion
- Motion in uniform electric and magnetic fields
- Motion in crossed fields
- Field invariants and classification of field configurations
- Motion in electromagnetic waves

**Module 4: Electromagnetic Radiation & Energy-Momentum Tensor** **(15 L)**

- Radiation
- Larmor formula and Liénard formula
- Angular distribution of radiation
- Near, intermediate, and radiation zones
- Synchrotron radiation, bremsstrahlung
- Cherenkov Rsdiation
- Energy–Momentum Tensor
- Electromagnetic stress-energy tensor $T^{\mu\nu}$
- Conservation laws: $\partial\mu T^{\mu\nu} = 0$
- Poynting vector, momentum density

- Radiation pressure and energy flow
- Electromagnetic field tensor $F^{\mu\nu}$

**Module 5: Fields in Media & Advanced Topics (13L)**

- Electromagnetic fields in moving media
- Covariant constitutive relations
- Introduction to plasma physics, (MHD Equations)
- Debye Screening Length, Quasi-neutrality, Magnetic Pressure and Tension. Alfven waves. Plasma Oscillations. Long and Short wavelength limit of Plasma Oscillations.

***Suggested Textbooks***

***Primary Texts***

*Jackson – Classical Electrodynamics*
*Landau & Lifshitz – The Classical Theory of Fields*
*Greiner – Classical Electrodynamics*

***Additional***

*Griffiths – Introduction to Electrodynamics*
*Schwartz – Principles of Electrodynaics*
*Panofsky & Phillips – Classical Electricity and Magnetism*

# SEMESTER – VIII
## MAJOR COURSE
## Experimental Techniques in Physics Course Code : BSCPHSMJ803

| Course Name | Course Type | Course Code | L-T-P | Course Credit | CA Marks | | ESE Marks | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Experimental Techniques in Physics | MAJOR | BSCPHSMJ804 | 2-0-4 | 4 | 30 | 15 | 20 | 35 | 100 |

***Course Objectives***

*In this course the students are introduced to statistical methods and statistical analysis of experimental data. They will learn about various statistical distributions used in diverse areas of physics, astronomy, geophysics, complex systems etc. They will also learn about measurements of various physical quantities like pressure, density, humidity, force, torque etc and estimate errors in experimental measurements. Finally they will learn about various kind of transducers used in device fabrication and various kinds of microscopy like STM, TEM, SEM etc.*

***Course Outcomes***

*Upon successfull completion of the course the students will learn about :*

- *Statistical methods in data analysis, various kinds of statistical distributions.*
- *Physical measurement of noise and signal and measurements of various physical parameters like pressure, density, force, torque, temperature etc.*
- *Error analysis and estimates of errors in physical measurements.*
- *Principle, construction and working of various kinds of transducers.*
- *Principles of optical microscopy and various advanced microscopy techniques like TEM, SEM, AFM and STM.*

## Course Content

**Data Analysis for Physical Sciences:** Population and sample, data distributions probability, probability distribution, distribution of real data, the normal distribution, from area under a normal curve to an interval, distribution of sample means, the central limit theorem, the t distribution, the log-normal distribution, assessing the normality of data, population mean and continuous distributions, population mean and expectation value, binomial distribution, Poisson distribution and Gaussian distribution.

**[10 L]**

**Error and Uncertainties:** Error analysis, true value and error, precision and accuracy, random and systematic errors, uncertainty in measurement, propagation of errors, combining uncertainties, expanded uncertainty, relative standard uncertainty, coping with outliers, weighted mean, least squares fitting, linear and nonlinear curve fitting, chi square test.

**[7 L]**

**Physical Measurements:** Types of instruments, performance and their characteristics, instruments calibration, noise and signals, length and angle measurements; pressure, level and density measurements; flow measurement, temperature and humidity measurements; mass, force and torque measurements.

**[5 L]**

**Transducers:** Classification of transducers - Principle, construction and working of thermistor, LVDT, resistive and capacitive transducers, photoelectric transducer, piezoelectric transducer, measurement of non-electrical quantities: strain, displacement, temperature, pressure, magnetic fields, vibration, optical and particle detectors.

**[5 L]**

**Microscopy:** Basic Principles of Optical Microscopy, Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM).

**[3 L]**

***Textbooks and References:***


1. *A. Bevan, "Statistical Data Analysis for the Physical Sciences", Cambridge University Press.*
2. *F. James, "Statistical Methods in Experimental Physics", World Scientific Publishing Company.*
3. *D. Placko, "Fundamentals of Instrumentation and Measurement", ISTE Ltd.*
4. *A. S. Morris, "Measurement and Instrumentation Principles", Butterworth-Heinemann.*


***Experiments:***

1 *Measure repeated fall times of a ball dropped from a fixed height. Plot histogram, fit Gaussian, and calculate confidence intervals.*

2 *Roll dice in groups of 1, 2, 5, 10. Plot distribution of sample means to show convergence toward normality.*

3 *Count radioactive decay events in fixed time intervals using a Geiger counter. Compare observed distribution with Poisson predictions.*

4 *Measure length and width of a plate, calculate area with uncertainties using error propagation formulas.*

5 *Test if experimental data follows Gaussian distribution using pendulum. Plot Histogram and perform chi-square test.*

6 *Use a U-tube manometer to measure gas pressure relative to atmosphere.*

7 *Record I–V characteristics of a resistor. Fit linear curve, calculate slope (resistance), and assess fit quality with chi-square test.*

8 *Build a voltage divider with a thermistor. Record resistance vs. temperature curve.*

9 *Use a photodiode to measure light intensity vs. output current.*

10 *Calibrate a thermocouple to measure unknown temperature.*

# SEMESTER – VIII
## MAJOR COURSE
## Advanced Electronics and Communication System

## Course Code: BSCPHSMJ804

| Course Name | Course Type | Course Code | L-T-P | Course Credit | CA Marks | | ESE Marks | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Advanced Electronics & Communication System | MAJOR | BSCPHSMJ804 | 2-0-4 | 4 | 30 | 15 | 20 | 35 | 100 |

***Course Objectives***

*The objective of this course is to provide students with a comprehensive understanding of advanced electronics and communication systems, specifically focusing on:*

- *Signal Processing and Transmission: Understanding the principles of various electronic filters and the fundamental behavior of transmission lines.*
- *Microwave Technology: Introducing solid-state microwave devices, including their operating principles and classification.*
- *Modulation Techniques: Developing a conceptual understanding of analog, pulsed, and digital modulation techniques used for signal transmission.*
- *Optoelectronics: Familiarizing students with the operational principles, structures, and characteristics of key optoelectronic devices.*

***Course Outcomes***

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

- *Analyze and Design Filters: Apply the theory of Constant-K filters (low-pass, high-pass, band-pass, and band-stop) to signal processing tasks.*
- *Evaluate Transmission Lines: Apply the Telegrapher's equations to analyze signal propagation, identify characteristics of transmission lines, and locate faults.*
- *Understand Microwave Devices:*
- *Explain the working principles and characteristics of microwave components such as Gunn diodes (including RWH theory and mode classification) and IMPATT diodes.*
- *Analyze Modulation Systems: Comprehend and compare different modulation schemes, including Amplitude (AM), Frequency (FM), and Phase (PM) modulation, as well as digital techniques like ASK, FSK, and PSK.*
- *Examine Optoelectronic Components: Explain the structural and operational characteristics of LEDs, photodiodes (including the avalanche mechanism), and the basic operation of solar cells.*

## Course Content

**Filters:** Constant-K filter, low pass, high pass, band pass and band stop filters.
Primary constants of transmission lines, Telegrapher's equations and its solutions, distortion less propagation, location of the fault on the line.

**[5L]**

**Solid state microwave devices:** Microwaves, Gunn diode, RWH theory, differential negative resistance, Mode classification criterion, modes in Gunn diode (fundamental concepts only), IMPATT diode: working principle.

**[5L]**

**Analog Modulation:** Need of modulation, Mathematical description of AM signal. Modulation index, spectrum of AM, upper and lower side frequencies. Power content, AM modulator and demodulator, DSBSC, SSB and VSB modulation (Fundamental concepts only, no analysis required).
Frequency Modulation: Theory of FM, Spectrum of FM, Band width, Frequency modulators and demodulators.
Phase Modulation: Definition of Phase Modulation (No Mathematical Analysis), Comparison of AM, FM, and PM.

**[10L]**

**Pulsed and Digital modulation technique:** Digital vs Analog transmission, Sampling theorem, Basic concepts of PAM, PWM, PPM (only definition and graphical concepts). Pulse code modulation and quantization. Digital modulation: ASK, FSK, and PSK mathematical and graphical representations.

**[5L]**

**Optoelectronic Devices:** LEDs, Working principal, structure and characteristics, Photodiodes: Working principal, structure and characteristics, Avalanche mechanism Solar cell: Basic principle of operation only.

**[5L]**

**Laboratory Experiments:**

1 To design a constant K low pass filter and its impedance curve.
2 Frequency response of active first order low pass filter using OPAMP.
3 To draw the static characteristics of a transistor to determine hybrid parameters.
4 To measure the input off-set voltage, Off-set current and input bias current of an OPAMP
5 To draw the drain characteristics of a FET to determine FET parameters.
6 To construct a simple power supply using ICS
7 To draw the characteristics of Gunn diode
8 To draw the characteristics of Tunnel diode
9 Studies on amplitude modulation system
10 Study of Schmidt trigger as a comparator.
11 Studies on OPAMP based astable multivibrator
12 Studies on 555 timer as inverting buffer or NOT gate
13 Studies on weighted resistor DAC using OPAMP
14 Studies on RC phase shift oscillator
15 To draw the characteristics of Solar cell.

***References :***

1 *Network Lines and Fields by John D Ryder, Pearson*
2 *Schaum's outlines in Electronic Communications, Lloyd- Schultz, Mc Graw Hills.*
3 *Advanced Electronic, Taraprasad Chattopadhyay, CBS Publishers*
4 *Microwave Devices and Applications, Dinesh C Dube, Narosa Publishing*
5 *Advanced Practical Electronics, Kar, Books and Allied*
6 *Advanced Electronic Practicals , A B Bhattacharya, New Central Book Agency*

# SEMESTER – VIII
## MINOR COURSE
## Modern Physics II

## Course Code: BSCPHSMN801

| Course Name | Course Type | Course Code | L-T-P | Course Credit | CA Marks | | ESE Marks | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Practical | Theory | Practical | Theory | |
| Modern Physics II | MINOR | BSCPHSMN801 | 4-1-0 | 5 | 00 | 30 | 00 | 70 | 100 |

***Course Objectives :***

*In this course the students will learn about fundamentals of nuclear physics like radioactivity, nuclear reaction and nuclear structures, especially the nuclear forces and various kinds of nuclear models like liquid drop model and shell model. They will also learn about elementary condensed matter physics like crystal structures and various kinds of chemical bonding. Interesting and exotic properties like superconductivity, magnetism and semiconductors will also be introduced in this course. Finally, students will learn about special theory of relativity and its implications.*

***Course Learning Outcomes:***

*This course aims to provide the students a comprehensive understanding of the fundamental principles of Nuclear Physics. Upon successful completion of the course, the students will be able to describe the fundamental concepts of crystal structure, different types of intermolecular bonding and band structure in solids. They will clearly articulate the magnetic properties of crystalline structures and the principle of superconductivity. They will also be familiar to the Special theory of Relativity and its consequences such as length contraction, time dilation, relativistic mass and mass-energy equivalence.*

## *Course Content:*

## Theory (60 Lectures)

**Nuclear Physics**

*Nuclear Structure:* (a) Constituents of nucleus and their Intrinsic properties. Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. (b) Nature of nuclear force, NZ graph. (c) Nuclear Models: Liquid Drop model. Semi-empirical mass formula and binding energy. Nuclear Shell Model. Magic numbers. [10L]

*Radioactivity*: Radioactive decay law. Half life and mean life. Activity of a radio sample. Radioactive dating. [3L]

*Nuclear Reactions*: Types of Reactions, Conservation Laws, Kinematics of nuclear reactions: Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, Nuclear fission and nuclear fusion.

[7L]

**Condensed Matter Physics**

*Crystal Structure*: Crystalline nature of solid, Miller indices, lattice planes, simple cubic, FCC and BCC lattices. Diffraction of X-ray, Bragg's law; Moseley's law: explanation from Bohr's theory. Continuous and characteristic X-ray.

[10L]

*Structure of solids*: Different types of bonding: ionic, covalent, metallic, Van der Waals and hydrogen. Elementary ideas about band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions). Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient.

[10L]

*Magnetic Properties of Matter*: Dia-, Para-, and Ferromagnetic Materials. Domains. Curie's law (Only statement), Hysteresis in Ferromagnetic Materials, Hysteresis Loss.

[4L]

*Superconductivity*: Critical Temperature. Critical magnetic field. Meissner effect. Type-I and Type-II superconductors [4L]

**Special Theory of Relativity**

Michelson-Morley experiment (outcome only) and discussion of the result, Postulates of special theory of relativity, Lorentz transformation formula. Length contraction. Time dilation.
Relativity of simultaneity. Addition of velocities. Variation of mass with velocity. Equivalence of mass and energy. [12L]

***References/ Suggested Readings:***


1 *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. R. Eisberg and R. Resnick (Wiley)*
2 *Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, .*
3 *Atomic and Nuclear Physics by S.N. Ghosal (S. Chand & Co.)*
4 *Introductory Nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd)*
5 *Introduction To Solid State Physics by C. Kittel (Wiley Eastern Ltd)*
6 *Solid State Physics by S. O. Pillai (New Age Publication)*
7 *Introduction To Special Relativity by Robert Resnick (Wiley)*
8 *The Special Theory of Relativity by Sriranjan Banerjee and Asit Banerjee (Prentice Hall India Learning Pvt Ltd)*

## COURSE TYPE: RP
## COURSE NAME: RESEARCH METHODOLOGY AND ETHICS
## COURSE CODE: BSCPHSRP801

<table>
<tr><td>Course Type: RP</td><td colspan="2">Course Details: RPC-1</td><td colspan="2">L-T-P: 4-0-0</td></tr>
<tr><td rowspan="3">Credit: 4 (Theory)</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>00</td><td>30</td><td>00</td><td>70</td></tr>
</table>

***Course Objective:*** *The objective is to impart into the students the theoretical idea and understanding on research and its methodology particularly of reviewing and surveying literature, writing research report with required format; testing of hypotheses and sampling for analysis and quantification research outputs, etc in maintaining research ethics.*

***Course outcome:***
*After completion of the course the students will be able to*

- *describe important ideas, concepts, and research styles, such as mixed, qualitative, and quantitative approaches*
- *create testable hypotheses or research questions, outline research challenges, and identify research gaps*
- *create a well-thought-out research plan that includes sampling strategies, data gathering procedures, and the right instruments for data processing*
- *use citing tools correctly, synthesize current research findings, and critically evaluate academic literature*
- *plan and carry out investigations involving human or animal subjects by applying ethical principles and comprehending the ethical issues in research*
- *evaluate data and interpret the findings in a meaningful way by using fundamental statistical or thematic analysis and approaches*
- *compose well-organized research papers or reports and explain their findings either orally or visually as well as to gain the capacity to evaluate research papers and procedures critically for validity, reliability, and limitations*
- *maintain research ethics although his/her research activities*

## *Course Content*

**Introduction to Research Methodology**
Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Criteria of good Research, What is Research Problem? Basic and Applied research

15 L

**Review of Literature and Literature survey**
Meaning and Purpose of the Literature Review & Literature Survey, Identification of the related Literature.

15 L

**The Research Report**

General format of the Research report, style and formatting of writing, typing of the research report.

15 L

**Testing of Hypotheses and Sampling design**

Definition, Concepts Concerning Testing of Hypotheses, Formulation of hypotheses and related difficulties; Needs of sampling, Random sampling.

15L

**Research ethics**

Research Ethics: Ethical principles and responsible conduct of research (RCR); integrity, transparency, and accountability in scientific research. Scientific misconduct (fabrication, falsification, plagiarism), publication ethics, authorship, peer review, and data management. Ethical issues in human and animal research, informed consent, confidentiality, IEC/IRB approval, conflict of interest, and researcher responsibilities

15 L

**Quantification of research output**

Impact Factor, *h*-index, *i10*-index and *i20*-index, *G*-index

15 L

***Recommended books/ Journals:***


- *C R Kothari, Research Methodology: Methods and Techniques, New Age International (P)Ltd. (2010), New Delhi Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction toResearch Methodology, RBSA Publishers.*
- *Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.*
- *W.M.K.Trochim, 2005. Research Methods: the concise knowledge base, AtomicDog Publishing. 270p.*
- *Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications*
- *Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.*
- *G Kanji, 100 statistical tests, Sage Publications.*
- *R. A. Day (1992) How to write and publish a scientific paper. Cambridge University press. London.*