Programme Name: B.Sc. (Hons.) Physics

Programme Objectives (POs):

B.Sc. (Hons.) Physics programme provides a strong base for students in fundamental knowledge of physics through the core courses namely Modern Physics, Wave Optics, Electrodynamics, Classical Mechanics, Relativity, Thermodynamics, Plasma Physics, Solid state Physics and Quantum Mechanics. The course is designed by Magadh University which help the students to have a good understanding of the subjects and help them in competing the various exams.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

This undergraduate programme in Physics includes theories, experiments and concepts of physics based subjects. After completing B.Sc. in Physics, various opportunities are available for the candidates.

PSO1: The Students will be able to demonstrate both an understanding and the practical application of ethical standards as well as scientific temperament in public and private life.

PSO2: Either, they can opt for higher education, i.e. M.Sc. or they can go for a job in the relevant field.

PSO3: There are a number of job opportunities available for a B.Sc. Physics graduate such as Physicist, Physics lecturer, Lab Assistant and Scientist etc.

PSO4: After the completion of B.Sc. degree course, Students can appear in national level entrance tests like IIT-JAM, JEST, TIFR-GS through which they can take admission in top institutes like IIT and IISER in India.

S. No.	Paper code	Title of Paper	Marks
B.Sc. Part-I			
1	Paper-I	Unit(A) Special Theory of Relativity Unit (B) Mechanics and Properties of Matter	**75**
2	Paper-II	Thermal Physics	**75**
3		Practical Paper	**50**
B.Sc. Part-II			
1	Paper-III	Unit (A) Optics Unit (B) Electromagnetic Theory	**75**
2	Paper-IV	Unit (A) Electrostatics and Magnetism Unit (B) Current Electricity Unit (C) Modern Physics	**75**
3		Practical Paper	**50**
B.Sc. Part-III			
1	Paper-V	Unit (A) Method of Mathematical Physics Unit (B) Classical Mechanism Unit(C) Quantum Mechanics	**100**
2	Paper-VI	Unit (A) Statistical Physics Unit (B) Electronics	**100**
3	Paper-VII	Unit (A) Plasma and classical electrodynamics Unit (B) Solid State Physics Unit (C) Physics of Atoms , Molecules and Nuclei	**100**
4		Practical Paper I Practical Paper II	**50** **50**

B.Sc. (Hons) Part-I

Paper-I

Unit (A): Special Theory of Relativity
Unit (B): Mechanics and Properties of Matter

Course Outcomes:

After completed this course, students will be able to:

CO1: Explain the concept of relativity, Lorentz transformations, length contraction, time dilation.

CO2: Study the relativistic transformation of velocity, variation of mass with velocity and mass energy equivalence, Doppler’s effect.

CO3: Understand the concept of inertial and non-inertial system, Coriolis force, central force motion, wave motion, lagrangian mechanics, Elasticity, Surface tension and viscosity etc.

Syllabus of Paper-I

Full Mars: 75

Unit A: Special Theory of Relativity

- Galilean transformations, inertial frames of reference. Michelson-Morley Experiment. Lorentz- Fitzgerald contraction, Einstein postulate, Lorentz transformations and its consequences. Lorentz-contraction. Time-dilation. Relativistic addition of velocities. Dragging of light by moving medium relativistic. Relativistic Doppler effect for propagation of light waves. Aberration of light. Variation of mass with velocity. Mass energy relation.

Unit B: Mechanics and Properties of Matter

- Inertial frame of reference and Non-inertial frames of references. Fictitious (Coriolis & centrifugal force) forces and their applications. Generalized coordinates, Constraints (holonomic-nonholonomic) D-Alembert principle and Lagrange’s equation of motion, Hamilton’s equation of motion and their simple applications.
- Gravitational potential and field due to bodies of regular geometrical shape. Motion in central field, Keppler’s laws, two particle motions in central field.
- Elasticity and elastic constants, Relation between Elastic constants, Bending of beams and cantilevers, torsion of cylinder and rigidity modulus by flat spring, Non spring effect of temperature and pressure on elasticity.
- Surface tension and surface energy, Principle of virtual work and its application to surface tension. Ripples and gravity waves. Surface tension by the method of ripple. Effect of temperature and pressure on surface tension.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
3. Mathur, D.S. 2005, Elements of Properties of Matter, S. Chand& Company Ltd., New Delhi.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

Paper-II
Unit A: Kinetic theory of Gases
Unit B: Thermodynamics

Course Outcomes:

On completion of this course, Students will be able to:

CO1: Calculate the different measures of speeds in the Maxwell Boltzmann Distribution of velocities and derive the transport coefficients of Thermal conductivity, Viscosity and Diffusion in ideal gas.
CO2: Apply first law of thermodynamics to calculate heat, internal energy, enthalpy and work done of various thermodynamics process and systems.
CO3: Describe the reversible and irreversible process, Carnot's theorem, Classiuss inequality entropy, second law of thermodynamics and Maxwell's equations.
CO4: Explain the black body radiation, Stefan's law and Einstein and Debye theories of specific solids.

Syllabus of Paper-II

Full Mars: 75

Unit A: Kinetic theory of Gases

- Description of Maxwell's law of distribution of velocities and its experimental verification. Equipartition of energy, Mean free path.
- Transport Phenomenon in Ideal Gases: Viscosity, Thermal Conductivity and Diffusion. Brownian motion, Langevin and Einstein's theories and experimental determination of Avogadro's number.
- Rectilinear flow of heat in metal rod conductivity by periodic flow method, Relation of thermal and electrical conductivities Vander Wall equation of state.

Unit B: Thermodynamics

- Zeroth Law of Thermodynamics and Concept of Temperature, First Law of Thermodynamics. Carnot Cycle, Carnot engine and Carnot theorem, Absolute scale of temperature, Clausius Theorem & Inequality, Concept of Entropy, Entropy Changes in Reversible and Irreversible processes, Enthalpy, Helmholtz & Gibb's Functions, Gibbs Helmholtz equation, Maxwell's equation and its application to simple physical problem.
- Thermodynamic description of phase transition, Chemical potential, Latent heat of transition, Clausius-Clapeyron equation, Ehrenfest scheme of phase transition.
- Joule-Thomson effect Liquification of gasses with special reference to hydrogen and helium. Production and measurement of low temperature.
- Black body radiation, Kirchhoff's law, Stefan law, Wien law, Planck law and its experimental verification.
- Einstein and Debye theories of specific heat of solid.

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
3. Basic and applied Thermodynamics, P.K. Nag, 2005, Tata McGraw-Hill company Ltd.

Web Resources:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html.
2. https://nptel.ac.in/

B.Sc. (Hons) Part-II

Paper-III
Paper title:
Unit (A): Optics
Unit (B): Electromagnetic theory

Course Outcomes:
After completed this course, students will be capable to:

CO1: Estimate cardinal points, focal length of the lenses.
CO2: Understand the interference phenomenon, applications of interference in design and working of interferometers.
CO3: Get an idea of diffraction phenomenon and to study Fraunhofer and Fresnel diffraction.
CO4: Understand the resolving power of different optical instruments.
CO5: Understand the idea of various kinds of polarization of light wave and their detection.
CO6: Gain knowledge in basic principle and application of laser.

Syllabus of Paper-III

Full Mars: 75

Unit-A: Optics

- Format's principle and mirror and lens formula, Cardinal points of thick lens and thick lens formula.
- Interference phenomena by division of amplitude form and division wave front. Michelson Interferometer, Febary-perot Interferometer, L.G. Plate and Echelons Grating.
- Diffraction: Fresnel's & Fraunhoffer's diffraction. Half period zones. Zone plate. Fresnel diffraction at straight edge and single narrow wise. Fraunhoffer's diffraction at slits and circular aperture. Plane diffraction grating, Concave grating and Eagles mounting grating. Resolving power of prism, telescope and microscope, Carnu's spiral and its use in diffraction problem.
- Production of Plane, Circularly and Elliptically Polarized Light. Nicole Prism, Quarter wave plate, Babiner's compensator analysis of elliptically polarised light. Rotatory Polarization and polarimetre. Principle of Laser action, Ruby Laser, He-Ne Laser.

Unit- B: Electromagnetic Theory

- Maxwell's field equations, pointing vector, electromagnetic momentum, Maxwell's stress tension, Pressure of radiation, Plane electromagnetic waves; Reflection and total internal reflection of polarised light, Double reflection in crystal. Theory of dispersion, optical properties of metal and dispersion in metals. Scattering by free and bound charge.

Reference Books:

1. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill.

2. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

Paper-IV

Paper title:

Unit (A): Electrostatics and Magnetism
Unit (B): Current electricity
Unit (C): Modern Physics

Course Outcomes:

On successfully completion of this course, students will be capable to:

CO1: Understand the concept of boundary conditions and apply to calculate the electric field in different media.
CO2: Apply the Poisson's and Laplace equations to calculate the electric field, potential and charge density.
CO3: Understand dielectric and magnetic properties of matter.
CO4: Use various network theorems to solve complex electrical circuits.
CO5: Understand de-Broglie wavelength and dual nature of matter.
CO6: Calculate problems related to dual nature and Heisenberg uncertainty principle.

Syllabus of Paper-IV

Full Mars: 75

Unit A: Electrostatics and Magnetism

- Boundary condition at the surface of separation of two dielectrics and refraction of line force.
- Scalar potentials in electrostatics. The potential of a system of charges; Dipole and quadrupole moment energy stored in an electrostatics field Poisson's and Laplace's equation in Cartesian, polar and cylindrical coordinates and their solutions for simple geometries dielectric polarisation. Relation between D, E & P.
- Properties of ferromagnetic material. Hysteresis curve method for obtaining B.H. curve, Energy loss per cycle of magnetisation, Magnetic circuit and application to electromagnet. Measurement of Magnetic flux density(B) by(a)B.C. and search coil (b) Grassot flu meter Energy stored in a magnetic field measurement of susceptibility of liquid by Quinks's method Langvin's and Weiss theories of dia, para and ferromagnetism.

Unit B: Current Electricity

- Thermodynamic treatment of seeback, Peltier and Thomson effect and their application, self inductance and mutual inductance. Growth and decay of current in circuits containing L.C and R. Simple applications of these circuits. Moving coil galvanometer, periodic and ballistic galvanometers. A.C. and A.C. circuit: Use of vectors and complex number in A.C. circuit theory series and parallel resonant circuit. Power in A.C. circuits, Watt meter A.C. Bridges (i) De Sautys Bridge (ii) Anderson Bridge (iii) Carey Foster Bridge (iv) Schering Bridge. Three phase A.C. system, mutually coupled circuits rotating magnetic fields poly phase and single phase induction motors. The transformer equipment circuit and vector diagram, Iron and Copper losses its transformer.

Unit C: Modern Physics

- Measurement of charge by Millkan's method and specific charge of an electron by Thomson's method, Natural radio activity Rutherford Saddy's theory of radioactive decay Geiger Muller counters, Discovery of Neutron isotopes, Artificial Radio activity, Elementary idea about nucleus and its structure, Nuclear fission Reactors, Astons mass spectrograph cyclotron and Betatron. Photoelectric emission, Einstein photoelectric equation, Photoconductive and Photo-voltaic cells.
- Compton effect, Bragg's law and determination of X-ray wavelength, cathode ray oscilloscope and its uses in amplitude frequency and phase measurement solid state rectifier and one stage R.C. amplifier.
- Primary and secondary cosmic rays, Penetrating components of cosmic rays, Attitude and latitude variation of cosmic rays, Intensity E. W. Asymmetry cosmic rays showers Fossi curve outline of cascade origin of cosmic rays.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
3. Electricity and Magnetism, K. K. Tewari, S. Chand & Company Ltd.
4. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
5. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6. Modern Physics: Kenneth S. Krane, 1996, John Wiley & Sons.

B.Sc. (Hons) Part-III

Paper-V
Paper title:

Unit (A): Method of Mathematical Physics
Unit (C): Classical Mechanics
Unit (B): Quantum Mechanics

Course Outcomes:

On the completion of this course, students will be able to:

CO1: Solve problems related with vector calculus with the help of differential operators like gradient, curl, divergence and Laplacian in orthogonal curvilinear and their typical applications in Physics.
CO2: Learn different ways of solving second order partial differential equations and apply to solve the Laplace, Poissons and wave equations.
CO3: Understand the complex variables and complex function and use it to calculate residue and definite integrals
CO4: Understand the Lagrangian and Hamiltonian approaches and solve numerical problems in classical mechanics.
CO5: Learn about the kinematics and dynamics of rigid body in details and also understand the idea related Euler's equation of motion.
CO6: Gain knowledge in classical background of quantum mechanics and understand the concept of Poisson brackets and Hamilton Jacobi equation.
CO7: Understand the fundamental basis of quantum theory, the Schrodinger time independent and dependent equation and also understand the applications of simple harmonic oscillators, hydrogen-like atoms and angular momentum operators.

Syllabus of Paper-V

Full Mars: 100

Unit A: Method of Mathematical Physics

- Curvilinear co-ordinates. Cartesian, spherical and cylindrical co-ordinates. Orthogal transformation of co-ordinates, scalar, vector scalar and vector fields, divergence and curl, line surface and volume integrals, Theorem of Gauss, Stoke and Green, Tensor and its elementary properties.
- Partial differential equations and its solution by separation of variables, Laplace equation and its solution, wave equation and its solution. Poisson's equation and its solution.

- Functions of a complex variable, Couchy-Rieman equations. Poles and branch points, order of singularity, Laurent and Taylor’s expansion, Cauchy integral theorem, residue theorem integration of complex functions.

<u>Unit B:</u> Classical Mechanics

- Hamilton’s principle, Lagrange's equation. Principle of least Action. Conservation theorems and symmetry properties. Application of Hamiltonian dynamics to simple problem-charge particle in electromagnetic field (non-relativistic cases), Laws of motion of rigid bodies. Moments of inertia and products of inertia. Eulerian angles. Euler’s equation of motion of rigid body. Gyroscopic motion, Motion of symmetrical top canonical transformation. Examples of canonical transformation, contact transformation, Hamilton-Jacobi equation, Action angle variations.

<u>Unit C:</u> Quantum Mechanics

- Inadequacy classical mechanics, dual nature of radiation, De Broglie’s wavelength, concept of state. The correspondence principle of postulates of quantum mechanics, Eigen functions and Eigen values of Hamilton operators. Heisenberg uncertainty principle and its applications.
- Schrodinger wave equation and its physical meaning, its application to problems of free particle, transmission it particle through potential step, one dimensional square well particle in box. Linear harmonic oscillator, Rigid rotator, Hydrogen atom.
- Commutation rules of orbital angular momentum, their Eigen functions, eigen values, spin half angular momentum, Pauli spin matrices, Pauli’s spinors, symmetric and anti-symmetric wave function, Pauli’s exclusive principle.

<u>References Books:</u>

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier
2. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India
3. Classical Mechanics, J.C. Upadhyaya, Himalaya Publishing House, 2015.
4. Classical Mechanics, H. Goldstein, 3rd Ed. (Paperback), 2011, Pearson Education
5. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
6. Quantum Mechanics-Concepts and Applications, N. Zettili, 2009, Wiley.

Paper-VI

Paper title:

Unit (A): Statistical Physics

Unit (B): Electronics

Course Outcomes:

After completed this course, students will be able to:

CO1: Get a wide knowledge of a probabilistic description of nature at the microscopic level gives rise to deterministic laws at the macroscopic level

CO2: Understand the elementary concept of ensemble, phase space, entropy and thermodynamic probability, partition function and density and energy function in grand canonical ensembles and thermodynamics.

CO3: Understand Boltzmann, Fermi Dirac distribution and Bose-Einstein and their applications.

CO4: Understand the concept of basic analog and digital electronics and applications.

CO5: Gain the knowledge on the logic gates, different oscillator and basic of FORTRAN language.

Syllabus of Paper-VI

Full Mars: 100

Unit A: Statistical Physics

- The fundamental assumption of statistical mechanics, probability distribution and entropy. Partition function and its conversion to thermodynamics function. Sacur-Tetrode equation and Gibbs paradox, Elements of ensemble theory and Liouvilles theorem. Canonical ensemble and thermodynamics, Energy fluctuations in the canonical ensemble. Grand canonical ensemble and thermodynamics, Density and energy fluctuation in the Grand canonical ensemble, simple application of ensemble theories to perfect gas.
- Maxwell-Boltzmann distribution law, Fermi-Dirac Distribution Law, B-E distribution law and their applications. Radial distribution function and its relation to thermodynamics function. A brief introduction to first and second order phase transformation, critical exponent, ising model in zeroth approximation, Introduction to fluctuations. The probability of thermodynamics fluctuations.

Unit B

- **Electronics**
  Thermionic Richardson's equation and its experimental verification. Child-Langmuir Law, Schottky effect. Semiconductor devices, p-n junction and zenor diodes, BJT and

FET transistor, optoelectronic devices, photo device, LDR photovoltaic cell, photo transistor.

- **Circuits Theory**
  Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Superposition theorem, Thevenin theorem, Norton theorem, Maximum Power Transfer theorem. One part and two part networks (only h-parameter), T and pi equivalence of two part network, Ladder network and constant K filters (low, high and band pass) attenuators.
- **Solid State Electronics**
  Equivalent circuit of BJT and FET, Half wave and Full wave rectifiers. Power supply with reference to smoothing circuits and voltage stabilization by cold cathode valve and zener diode. A.F. amplifiers (R.C. coupled amplifier) Feedback amplifiers, Push-pull power amplifier, simple circuits for oscillation L.C.(Harlley and Colptts) oscillator, R.C. oscillator. Principle of amplitude of modulation, amplitude modulator, average and envelop detection, radio receivers, super heterodyne receiver, and simple idea of transmitter (with block diagram). CRO and its applications. Logic circuits, AND, OR, NAND, NOR operation with help of simple logic gates.
- Types of computer and three basic components. Input-output devices concept of hardware and software. BITS and BYTES computer programming of some simple mathematical problem, mathematical problem in BASIC and FORTRAN languages.

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall.
3. Elements of Electronics, M.K. Bagde, S.P. Singh and Kamal Singh, 2002, S. Chand & Company Ltd.
4. Pulse Digital and Switching Wave forms, J. Millman, and H. Taub, Tata McGraw Hill, (1991)
5. D. A. Bell, Electronics Devices and Circuits, Oxford University, (2008).
6. R.L. Boylestad, and L. Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall of India, (2007)

Paper-VII

Paper title:

Unit (A): Plasma and Classical Electrodynamics
Unit (B): Solid State Physics
Unit (C) Physics of Atoms, Molecule and Nuclei

Course Outcomes:

On the completion of this course, students will be able to:
CO1: Get knowledge of Plasma Physics, source of plasma and their applications.
CO2: Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density.
CO3: Familiarize about Retarded potential, Lienard-Wiechards potentials and fields and also achieve an understanding of covariance of Maxwell's equation under Lorentz transformation.
CO4: Gain the knowledge of the crystal structures through crystallographic parameters.
CO5: Elucidate the important features, and to differentiate between different types of matter depending on the nature of chemical bonds and their properties.
CO6: Grasp the concept of free electron theory of metal, Bloch's theorem, energy bands are and the fundamental principles of semiconductors.

Syllabus of Paper-VII

Full Mars: 100

Unit A: Plasma and Classical Electrodynamics

- Microscopic and macroscopic properties of plasma, plasma oscillations, Debye's potential. Wave propagation in isotropic plasma. Ionospheric reflections pitch effect. Alvin wave, Shah's theory of ionisation.
- Retarded and advanced potential, field due to an oscillating current element, oscillating dipole Linar-Wichart potentials. Potential and field due to uniformly moving charge.
- Covariance of Maxwell equations under Lorentz transformation. Transformation equations of electromagnetic fields.

Unit B: Solid State Physics

- Elements of crystallography, Bravias lattice, Milller indices, seven crystal system, simple crystal structure and NaCl, CaCl2, and diamond.
- Introduction of X-rays, Neutrons and electrons with matter, Diffraction of X-rays from a perfect crystal, Bragg's law reciprocal lattice, Ewald construction and Brillion zones.
- Crystal binding ionic, metallic covalent and VanderWall's binding VanderWall's London interaction and cohesive energy of inert gas crystal. Medelung energy and Madelung constant.

- Free electron theory of metals. Heat capacity of electron gas. Electrical conductivity of metals, Boltzmann-Transport equation. Somerfield theory of electrical conductivity, band theory of solid, Bloch's theorem, Kroning-Penny model. Distinction between metal, semiconductor and insulator, intrinsic and extrinsic semiconductors, p-n junction rectifier, Hall effect.

Unit C: Physics of Atoms, Molecules Nuclei

- Origin of atomic spectra, Bohar's theory and Bohar-Sommerfield theory of hydrogen atom, spectra of alkali and alkaline earth metals, selection rules, fine structure, Stern Gerlach experiment, vector model of atom, Zeeman effect and Paschan Back effect. Mosely's law, origin of X-ray spectra.
- Rotational and vibrational spectra of diatomic molecules, Rotation, vibration and electronic bands, NMR and ESR Spectroscopy.
- General properties of nuclei: nuclear mass, nuclear charge, spin, parity, nuclear magnetic dipole moment, size of the nucleus and stability. Nuclear models liquid drop model and mass formulae. The shell model. Classical theory of Rutherford scattering.

Reference Books:

1. Fundamentals of Plasma Physics, J.A. Bittencourt, Third edition, Springer Publication, 2004.
2. Introduction to Electrodynamics, David J. Griffiths, Prentice-Hall of India, Third Edition, 2009.
3. Solid State Physics, M.A. Wahab, 2011, Narosa Publication.
4. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
5. Solid State Physics, R.K, Puri, V.K. Babbar, S. Chand & Company Ltd.
6. Introduction to Atomic Spectra, White, H.E. (McGraw-Hill).
7. Molecular structure and Spectroscopy, G. Aruldhas, Prentice Hall of India, New Delhi, 2001.
8. Introductory Nuclear Physics, Kenneth S. Krane, Wiley India Pvt. 2008.