J. S. UNIVERSITY

Shikohabad, Firozabad (U.P.)

MASTER OF SCIENCE (M.Sc.)

(TWO YEAR DEGREE COURSE)

Code-202

PROGRAMME BROCHURE
PHYSICS

2017

The POs of Master in Science Programme are:

1. Programme Objectives

The core objectives of Master of Science programme in Physics:

- ✓ M.Sc. Physics Programme with manifold objectives, is aimed at imparting students with comprehensive knowledge and better understanding in theoretical as well as experimental aspects of physics through the core and elective courses, for holistic development.
- ✓ The core courses have been designed to encourage scientific approach and problem-solving abilities, whereas the elective and open elective courses are structured with specialized and/or interdisciplinary content to equip students with a broader knowledge base.
- ✓ The elective labs are intended for appreciation for the fundamental concepts and working of devices using tools of physics for augmenting Practical and Theoretical knowledge.
- ✓ The Master Dissertation project is intended to give an essence of research work for excellence in specific areas.

2. Programme Outcomes

The prime outcomes of Master of Science programme in Physics:

- ✓ Empowering the students to analyze mathematical models of physical systems and critically analyze the limitations.
- ✓ Promoting the skills of problem solving, developing analytical approach to equip students with improved resilience and matured professional perspective.
- ✓ Developing discipline-specific expertise, like self-directed scientific literature analysis, and apply it to pursue their research career.

3. Specific Programme Outcomes

The Master of Science programme in Physics imparts students with:

- ✓ Knowledge to comprehend and appreciate a great variety of phenomena occurring in the Universe, both at micro and macroscopic level in non- relativistic as well as relativistic realm through understanding of basic concepts of Physics.
- ✓ Exposure to research within one of the research areas represented at the
- ✓ Department of Physics, through supervised Master Dissertation project.
- ✓ Adequate analytical skills on the advanced levels of Physics, needed for plethora of job opportunities in education, research, and industry.
- ✓ Competence in core areas of Physics, which is in line with the international standards, aimed at realizing the goals towards skilled India.

Course Structure for M.Sc. Previous (Physics) under Annual System

Note*: There will be four theory papers of 100 marks each and a practical examination of 200 marks. Each written paper shall consist of five units.*

MSP- (101) Paper I- Mathematical & Computational Methods in Physics	100 marks
MSP - (102) Paper II- Classical Mechanics & Statistical Mechanics	100 marks
MSP - (103) Paper III- Atomic and Molecular Physics	100 marks
MSP - (104) Paper IV- Electrodynamics and Plasma Physics	100 marks
MSP - (105) Practical based on the papers	200 marks

Total - 600 Marks

MSPH- 101 **Paper I- Mathematical & Computational Methods in Physics**

Unit I

Vector spaces and Matrices, linear independence, Bases, Dimensionality, Inner/product, Linear transformations, Matrices, Inverse, orthogonal and unitary matrices, Independent elements of a matrix, Eigen values & Eigen vectors, Diagonalization, Complete orthonormal Sets of functions.

Unit II

Differential Equations and special Function, Second order linear ODES with variable coefficients, Solution by series expansion, Legendre, Bessel, Hermite and Laguerre equations, Physical applications, Generating functions, recursion relations.

Unit III

Integral Transforms, Laplace transform, First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function, Fourier series, FS or orbitrary period, Half wave expansion, partial sums, Fourier integral and transformes FT of delta function.

Unit IV

Methods for determination of zeroes of linear and non-linear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative method, matrix inversion. Eigenvalues and eigenvectors of matrices, Power and Jacobi Method, Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic spline fitting.

Unit V

Numerical differentiation and integration, Newton-cotes formula, error estimates, Gauss method. Random variate, Monte carlo evaluation of integrals, Methods of importance sampling, Random walk and Metropolis method. Numerical solution of ordinary differential equations. Euler & Runge Kutta Methods, Predictor & corrector method. Elementary ideas of solutions of partial differential equations.

Course Outcomes: On completion of the course the student will be benefitted from the knowledge of vectors, matrices, and their properties. Students will be able to solve the differential equations and able to apply the different polynomials to solve the physical problems. Students will acquire the knowledge of Laplace and Fourier transforms and their applications. They will understand the significance of algebraic and transcendental equations. Students will be able to understand applications of numerical differentiation and integration methods and understand elementary ideas of differential equations.

<u>MSPH- 102 **Paper II- Classical Mechanics & Statistical Mechanics**</u>

Unit I

Mechanics of one and many particle systems (Newtonian mechanics), conservation laws, work-energy theorem, Constraints and their classification, Generalized Co-ordinates, D'Alembert's Principle, Langrange's Equations from D'Alembert's Principle for conservative and non-conservative system, Conservation theorem of energy, Gyroscopic forces, dissipative system, Jacobi integral, gauge invariance, integrals of motion, Symmetries of space and time with conservation laws, invariance under Galilean transformations.

Unit II

Rotating frames, Inertial forces, Terrestrial and astronomical applications of Coriolis force, Central force; definition and characteristics, Reduction of two body problem into a single body problem, General analysis of orbits, Kepler's laws and equation, artificial satellites; Rutherford Scattering, Principle of least action, Derivation of equations of motion, variation and end points, Hamilton's principle and characteristic functions; Hamilton-jacobi equation. Deduction of Lagrange's equation, Hamiltonian function and its physical significance, Hamiltonian canonical equations, cyclic-coordinates, Modified Hamilton's principle.

Unit III

Canonical transformation; Generating functions; properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum and Poisson brackets; Small oscillations; normal modes and coordinates. Foundations of Statistical mechanics; specification of states of a system, contract between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Unit IV

Ensembles and Microcanonical, ensemble, Phase space, trajectories and density of states, Canonical and grand canonical ensembles, Liouville;s theorem, Partition function, calculation of statistical quantities. Energy and density fluctuation. Density matrix, Maxwell-Boltzman, Fermi-Dirac and Bose Einstein Statistics, Properties of ideal Bose and Fermi gases, Gas Degeneracy, Bose-Einstein Condensation. Cluster expansion for a classical gas, virial equation of state, Ising model, mean field theories of the Ising model, in three, two and one dimensions, exact solutions in one dimension.

Unit V

Landau theory of phase transition, critical indices, scale transformation and dimensional analysis. Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, Fluctuation-dissipation theorem, Fokker-Plank equation, Einstein theory of specific heat of solids, Debye theory of specific heat of solids.

Course Outcomes: After completion of this course, the students will have the confidence to write the Lagrangian and Hamiltonian equations for any dynamic system. They would be able to learn to perceive the symmetries and associated conservation laws and their applications to solve a classical system. They will have the understanding to solve the problem based on Poisson brackets and small oscillations. Students will acquire the knowledge of thermodynamics and Statistical mechanics. They will have the potential to write the Maxwell-Boltzman, Fermi-Dirac, and Bose-Einstein Statistics for any system of particles. They would be able to extract the specific heat of the solids using the Einstein and Debye theories.

MSPH- 103 **Paper III- Atomic and Molecular Physics**

Unit I

Quantum states of one electron atoms-Atomic orbitals, Hydrogen Spectrum. Pauli's Principle spectra of alkali elements–spin orbit interaction and fine structure in alkali spectra. Magnetic moment of an atom, Lande g factor, Transition rules L-S and J-J Coupling, Single and triple spectra in alkaline earth. Penetrating and non-penetrating orbits.

Unit II

Equivalent and non-equivalent electrons-Normal and anomalous Zeeman Effect. Paschan Back effect, Stark effect, Pauli's Exclusion Principle and Periodic Table, Hyperfine structure. Magnetic quantum numbers.

Unit III

Types of molecules-Diatomic linear Symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotator. Energy levels and spectra of non rigid rotor intensity of rotational lines. Stark modulated microwave spectrometer (qualitative). Salient feature of Vibrational Spectra, Explanations considering molecule as harmonic oscillator.

Unit IV

Nature of Raman Effect, experimental arrangement, Quantum theory of Raman Effect, Pure rotational Raman Spectrum, Stokes and Antistoks lines, Raman Spectra and Molecular structure. Mechanism of Flourescent and Phosphores-cent Emission, Chemi Luminescence.

Unit V

Characteristics and continuous X-ray spectra, Kossel's Explanation of characteristic X-ray spectra, continuous X-ray spectra and its short wave length limit, X-ray emission Spectra, the Moseley Law, X-ray absorption spectra, Fine structure of absorption edges, Fine structure in X-ray emission Spectra. Screening and Spin relativity, Doublets, X-ray spectra and optical spectra.

Course Outcomes: After passing this course most of the students would be benefitted from the knowledge of atomic, and molecular spectra. They will apply the transition rules to the acquired spectra. They would be able to have a keen observation of the Raman scattering and X-ray characteristics and their applications.

MSPH- 104 **Paper IV – Electrodynamics and Plasma Physics**

Unit I

Galileo transformations, Review of Four vector and Lorentz Transformation in Four Dimensional Space, Electromagnetic Field tensor in Four Dimensions and Maxwell's equations, dual field Tensor, Wave Equation for vector and Scalar potential and solution retarded potential and Lienard Wilchert potential, Electric and Magnetic field due to a Uniformly Moving charge and an accelerated charge, Bremsstralling, Synchrotron Radiation and Cerenkov Radiation, Reaction force of Radiation.

Unit II

Motion of charged particle in electromagnetic field: Uniform E and B field, Non uniform field. Diffusion across magnetic field, time varying E and B field, adiabatic invariants: first second third adiabatic invariants.

Unit III

Potential in terms of charge distribution, Dipole interaction, Displacement vector, Boundary conditions, Electric field in a material medium, polarisability, Clausius Mossotti relation, Langevin's theory of dielectric polarization Piezo, Pyro and Ferro electricity. Solution of Laplace's equation in spherical Coordinates by separation of variables method, potentials of a point charges. A dielectric sphere in uniform field.

Unit IV

Concept of Plasma, Condition for plasma Existence, Occurrence of Plasma, derivation of moment equations from Boltzmann equation, Plasma oscillation, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma confinement. Hydrodynamical description of plasma: Fundamental equations. Hydromagnetic waves: Magnetosonic and Alfven waves.

Unit V

Wave phenomena in magneto plasma: polarization phase velocity, group velocity, cut offs resonance for electromagnetic wave propagating parallel and perpendicular to the magnetic field. Propagation at finite angle and CMA diagram, Appleton Hartee formula and propagation through ionosphere and magnetosphere Helicon, whistler Faraday rotation.

Course Outcomes: At the end of this course students would be able to have deep knowledge of Maxwell's equations and their application to deduce the wave equation, electromagnetic field energy, momentum, and angular momentum density. They would also be able to explain the phenomena that occurred due to the accelerated charged particles. Students would also have deep knowledge of plasma and its features and they would be benefitted from the knowledge of the phenomena due to the interaction of the electromagnetic wave with the plasma.

MSPH 105 M.Sc. (Prev.) Physics Practical

List of Experiments:

1. Study of visible spectrum by constant deviation spectrometer.
2. To determine the Stefen's constant.
3. To Study and verify the truth table for Logic gates.
4. Verification of truth table of Half and Full Adder.
5. To study the characteristic of common base transistor.
6. To study the characteristic of common emitter transistor.
7. To determine the velocity of ultrasonic waves in a liquid.
8. To determination of wavelength of monochromatic light by Michelson's interferometer.
9. To Study the Wein's Displacement law.
10. Study of basic circuits in the construction of computer.
11. Digital to analog converter & analog to digital converter.
12. To find the energy band gap of the material.
13. To study rotator dispersion of quartz.
14. Verification of digital transformation.
15. Determination of Hall constants of metal.
16. Study of multivibrator circuits.
17. Assembly of power supply.
18. Ripple factor for different electrical and electronic circuits.
19. Viscosity of a fluid by rotation/viscometer.
20. Verification of Fresnel's laws of reflection.

Distribution of marks:

Practical	100 marks
Viva –voce	60 marks
Record	40 marks
Total	200 marks

Course Outcomes: After completion of experimental works students would be able to apply the theory practically. They would be acquired deep knowledge of handling various scientific instruments like spectrometers, interferometers, viscometers, and so forth. They would be able to learn the working of transistors, diodes, logic gates, and their application in different circuitries. Students will also be able to determine the energy band gap and Hall constants of different materials.

Course Structure for M.Sc. Final (Physics) under Annual System

Note: *There will be four theory papers of 100 marks each and a practical examination of 200 marks. Each written paper shall consist of five units.*

MSP- (101) Paper I- Quantum Mechanics	100 marks
MSP - (102) Paper II- Nuclear and Particles Physics	100 marks
MSP - (103) Paper III- Basic and Digital Electronics and devices	100 marks
MSP - (104) Paper IV- Electronic Communication System	100 marks
MSP - (105) Practical based on the papers	200 marks

Total - 600 Marks

MSPH- (201) **Paper I- Quantum Mechanics**

Unit I

Operator algebra and Hydrogen Atom: Linear operators, Null operator, Identity operator, Singular and Non singular operator, Eigen functions and Eigen values, orthogonal Eigen functions, The operator formalism in quantum mechanics, Momentum operator, Hamiltonian operator, communication in operators, Hermitian operator, properties of Hermitian operator, Parity operator. Postulates of quantum mechanics, coordinate and momentum representation, superposition of Eigen states, continuous spectrum. Equation of motion. Ehrenfest's theorem, simultaneous measurements and commuting operators. Schwartz inequality, Heisenberg uncertainty relation derived from operator, commutator algebra. Commutation relation for L_X, L_Y, and L_Z Ladder operators. Completeness of Eigen functions Dirac-delta function, bra and ket notation. Matrix representation of an operator, unitary transformation. The Schrodinger equation for spherically symmetric potentials, Degeneracy, Hydrogen atom. Radial equation, Eigen value, radial probability.

Unit II

Approximation Methods: Stationary perturbation theory, Non-degenerate case, First order perturbation, second order perturbation, perturbation of an oscillator, Helium atom, Degenerate case, Removal of degeneracy in first and second order, First order Stark effect in hydrogen, weak field Zeeman effect. The variational method. Expectation value of the energy. Ground state of Helium. Exchange degeneracy. Heitler-London theory of hydrogen molecule. WKB method and its applications.

Unit III

Scattering Theory and Time Dependent Perturbation, scattering cross-section. Relation between angles, energies, etc. in laboratory and centre of mass system of co-ordinates, Normalisation of incoming wave, differential scattering cross-section. Partial waves and phase shifts. Optical theorem, Born approximation and its validity condition. Study of scattering from a square well potential and rigid sphere. Transition probability, density of continuum states, golden rule, Harmonic perturbation, second order perturbation.

Unit IV

Identical particles and Relativistic wave equations: Physical meaning of identity, Distinguishability of identical particle, symmetric and Antisymmetric wave functions, Connection of spin and statistics, collision of identical particles with spin, Pauli Spin matrices. Schrödinger relativistic equation for free particles (Klein Gordon equation), Dirac relativistic equation, free particle equation, Properties of Dirac matrices, Free particles solutions, Electron spin, Magnetic moment, Dirac equation of a central field of force, Spin-orbit coupling, Solution for hydrogen atom, Negative energy states.

Unit V

Quantum theory of radiation, Formulation in terms of transition probability, Matrix elements of the perturbation, Transition probability for absorption. Transition probability for emission, Einstein coefficients. Angular momentum, Integral and Half-integral angular momentum, Spin Eigen functions, Conservation rules, Coupling of two angular momenta, Clebsch-Gordon coefficients.

Course Outcomes: After completion of this course students would be able to differentiate the Classical and Quantum Mechanics. They will feel well equipped to understand the physics of the microscopic world. They would be at a stage where they could apply different operators on a quantum mechanical system to find out the energy, momentum and angular momentum, etc. Students will be able to have a great knowledge of perturbation theory, the variational method, and the WKB method to determine the energy of the system. They could solve problems based on scattering theory and probabilistic methods. Students will be able to apply the relativistic wave equations to solve the hydrogen-like atoms. They will be able to use microscopic systems to apply the quantum theory of radiation.

MSPH- (202) Paper II- **Nuclear and Particles Physics**

Unit I

Nuclear Interaction and Nuclear Reactions: Nucleon-Nucleon Interaction, exchange forces and tensor forces; Meron theory of Nuclear forces, Nucleon-nucleon scattering, Effective range theory. Spin dependence of nuclear forces, charge independence and charge symmetry of nuclear forces, Isospin formalism. Yukawa interaction. Direct and compound nuclear reaction mechanism. Cross-sections in terms of partial wave amplitudes-compound nucleus, scattering matrix, Reciprocity Theorem, Breit Wigner one level formula-Resonance scattering.

Unit II

Nuclear Models: Liquid drop model. Bohr wheeler theory of fission, Experimental evidences for shell effects, shell model, Spin orbit coupling. Magic numbers, angular momenta and parity of ground of nuclear ground states, Qualitative discussion and estimates of transition rates. Magnetic moments and Schmidt lines-Collective model of Bohr and Mottelson.

Unit III

Nuclear Decay: Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, angular momentum and parity selection rules-comparatives half lines allowed and forbidden transitions, selection rules parity violation. Two component theory of neutrino decay. Detection and properties of neutrino, Gamma decay, multipole transition in nuclei, angular momentum and parity selection rules, internal conversion nuclear isomerism.

Unit IV

Particle Detectors and Accelerators: (a) Detecting Instruments (electrical) Ionization chambers. Solid state detection, G.M. counter. Scintillation counter. (b) Wilson cloud chamber. Diffusion cloud chamber Bubble chamber.

Accelerators: (a) Proton synchrotron (Variable field and variable frequency) (b) Electron synchrotron and Betatron.

Unit V

Elementary Particle Physics: Types of interaction between elementary particles, Hadrons and leptons, Symmetry and conservation laws, elementary ideas of CP and CPT invariance. Classification of hadron, Lie algebra, SU (2) SU (3) multiplects, Quark model, Gell Mann-Okubo mass formula for Octel and decuplet hadron charm, bottom and top quarks.

Course Outcomes: At the end of the course most of the students would be benefitted from the theory of nuclear interaction and applications of nuclear reactions. They will be able to solve the problems based on nuclear models like a liquid drop model. Students will also be able to differentiate different nuclear decay processes like alpha, beta, and gamma decay. They will have learned the basic concepts, mechanisms, and applications of different particle detectors and accelerators. Students will also be able to identify the different fundamental particles based on their characteristics.

MSPH- (203) Paper III- **Integrated Circuits and Digital Electronics**

Unit I

Introduction to operational amplifier, basic parameters, applicability of OP-Amp in analog computation, OP Amp as Voltage Follower, Adder, Subtractor, Integrator, Differentiator, Log amplifier Antilog amplifier, Analog multimeter & Divider circuit. RMS circuit Function fitting and time function generation.

Unit II

Active filters, comparator, multivibrator, Schmitt Trigger, sample and hold circuit, Triangular wave generator, Voltage controlled Oscillator, Phase locked loop, Volage to Frequency and frequency to voltage converter, A/D and D/A converter circuit, 555 Timer. Noise in Ics.

Digital Electronics

Unit III

Number system, Codes (Grey code, ASCII code and BCD code), Basic circuit logic gate, DTL, RTL, TTL and ECL logic circuits, analysis and system of combination logic circuit. Karnaugh map, pairs, Quads and Octaves.

Unit IV

Arithmetic logic circuits, Half adder, Full Adder, Half Subtractor and Full Subtractor, controller, Inverter and adder Subtractor circuits, Data processing circuits, Multiplexers, Demultiplexers, Encoder and Decoder (1 to 16 Decoder, BCD decoder and LED decoder)

Unit V

Introduction to Flip-flop, R-S, D, T, J-K, and J-K master slave flip flops, synchronous and asynchronous counters, mod counters, Ring Counter serial and parallel shift registers, introduction to semiconductors memories, RAM, ROM, EPROM and three addressing techniques.

Course Outcomes: On the completion of this course the students will have a good knowledge of operational amplifier and their applications. They would be learned about the different electronic circuitries like comparator, oscillator, generator, converter, etc. Students will also be able to design digital electronic circuitries using logic gates. They will have the command on the application of different memories like RAM, ROM, and EPROM.

MSPH- (204) **Paper IV -** Electronic Communication System

Unit I

Analog & Digital Communication: Amplitude Modulation, Modulation and Demodulation Techniques, Frequency Modulation, Narrow and wide band frequency modulation, PLL as frequency demodulator, Phase modulation, Equivalence between AM, FM and PM modulation, Digital modulation, sampling and quantization, pulse code modulation, ASK, FSK, PSK and DPSK, frequency division and time division multiplexing.

Unit II

Microwave Electronics: Generation of microwave by reflex-Klystron and semiconductor gun diode, wave guide, cavity resonator, Microwave antenna, microwave detector, VSWR, power and dielectric measurement, Isolator directional Coupler magic Tee.

Unit III

Satellite & radar Communication: Basic of satellite communication, Satellite orbit, Satellite frequencies, Synchronous Satellite, satellite communication link factors affecting satellite communication, transponders, Basic radar system, types of radar, Pulsed radar, Moving target indicator radar, CW radar, radar cross section radar display, PPI duplexer radar antenna, Modern radar.

Unit IV

TV and Antenna System: TV system and standard, TV band width and channels, Interlaced scanning and video camera tube, TV transmitter and receiver, Colour Television, Antenna system, short electric doublets radiation from one pole and dipole arials, antenna arrays, Folded dipole application, Antenna parameters, Yagi Antenna, Parasitic antenna, Parabolic reflectors.

Unit V

Fiber Optic Communication: Wave propagation in an isotropic media, Transmission and fiber losses in fiber, Dispersion, optical wave guide, optical fiber source and detector, Coupler, Modern telephone optic mux.

Course Outcomes: Over the study of this course, students will have effective knowledge of the communication which is performed using electronic systems. They would be able to explain how modulation and demodulation occur in communication. They would be earned the knowledge of the working principles of satellite systems. Students will be able to understand the working of TV and antenna systems. They would be updated with the new optical communication system like fiber optical communication.

MSPH 205 **M.Sc. (Final) Physics Practical**

List of Experiments:

1. Characteristic of Field Effect transistor (FET)
2. Characteristics of SCR
3. Characteristics of UJT
4. 'h' parameters of Bijunction transistor (BJT)
5. Transistor bias techniques
6. Study of common emitter RCC amplifier
7. Study of FET amplifier
8. Study of feedback amplifier
9. Study of operational amplifier
10. Study of Wien Bridge Oscillator
11. Study of multivibrators
12. Study of Hartley Oscillator
13. Study of voltage power supply with filters
14. Study of current power supply with filters
15. Study of Zenner regulated voltage power supply

Course Outcomes: After completion of this experimental work students would be able to apply the transistors in different electronic circuitries. They might be capable to apply an amplifier as the oscillator. Students will be able to use the diode to make the voltage power supply.